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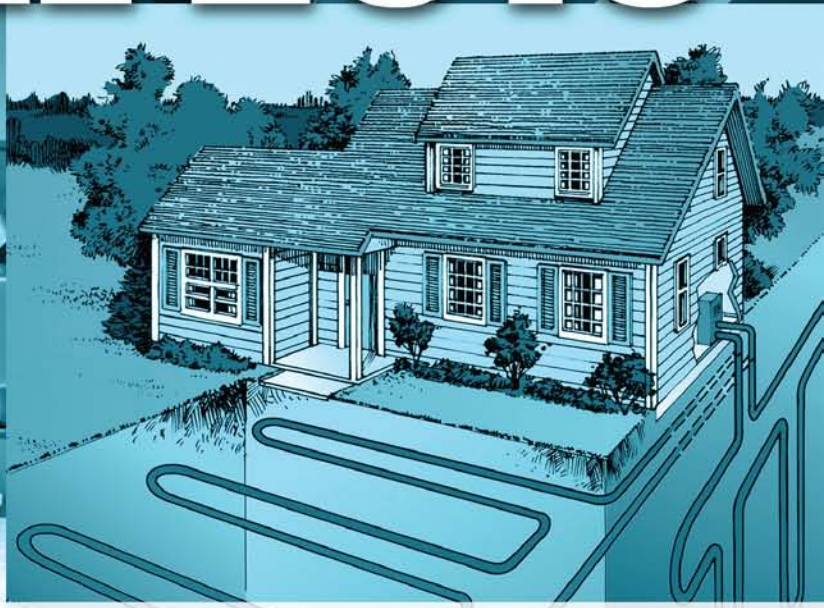

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Publisher's Letter

Energy efficiency improvement in centralized ACs is to have an intelligent control system

The Energy conservation is a major focus towards sustainable development & waste heat recovery is a very useful energy saving technique where the heat is removed by the refrigeration systems. Scientists & engineers are developing new technologies to recover & utilize waste heat from refrigeration systems. The article 'Technologies for Waste Heat Recovery from Refrigeration Systems' highlights the need and potential of waste heat recovery in refrigeration units and the latest technological developments.

On technology fronts, one of the primary methods of energy efficiency improvement in centralized ACs is to have an intelligent control system. The write-up 'Cooling technologies for Air conditioning systems for enhancing energy efficiency' explores the various technologies for enhancing the energy efficiency and reducing the electrical energy consumption of central air conditioners. The new energy reducing innovations in technology are the variable refrigerant flow and inverter driven compressor motors.

Further, as known a device facilitating heat transfer between two or more fluids at different temperatures is Heat exchanger. An article 'Heat Exchangers: Classification Design and Analysis' mentions that the rating and sizing of heat exchangers are the two important problems encountered in the thermal analysis of heat exchangers. The rating problem is concerned with determination of the heat transfer rate, fluid outlet temperatures, and the pressure drops for an existing heat exchanger that concerns with heat transfer surface area.

Do visit us at **ACREX 2015 at Stall 53B in Hall 12A.** Also find post event report of ICCS 2014.

Please send your comments at pravita@charypublications.in

Pravita Iyer
Publisher & Director

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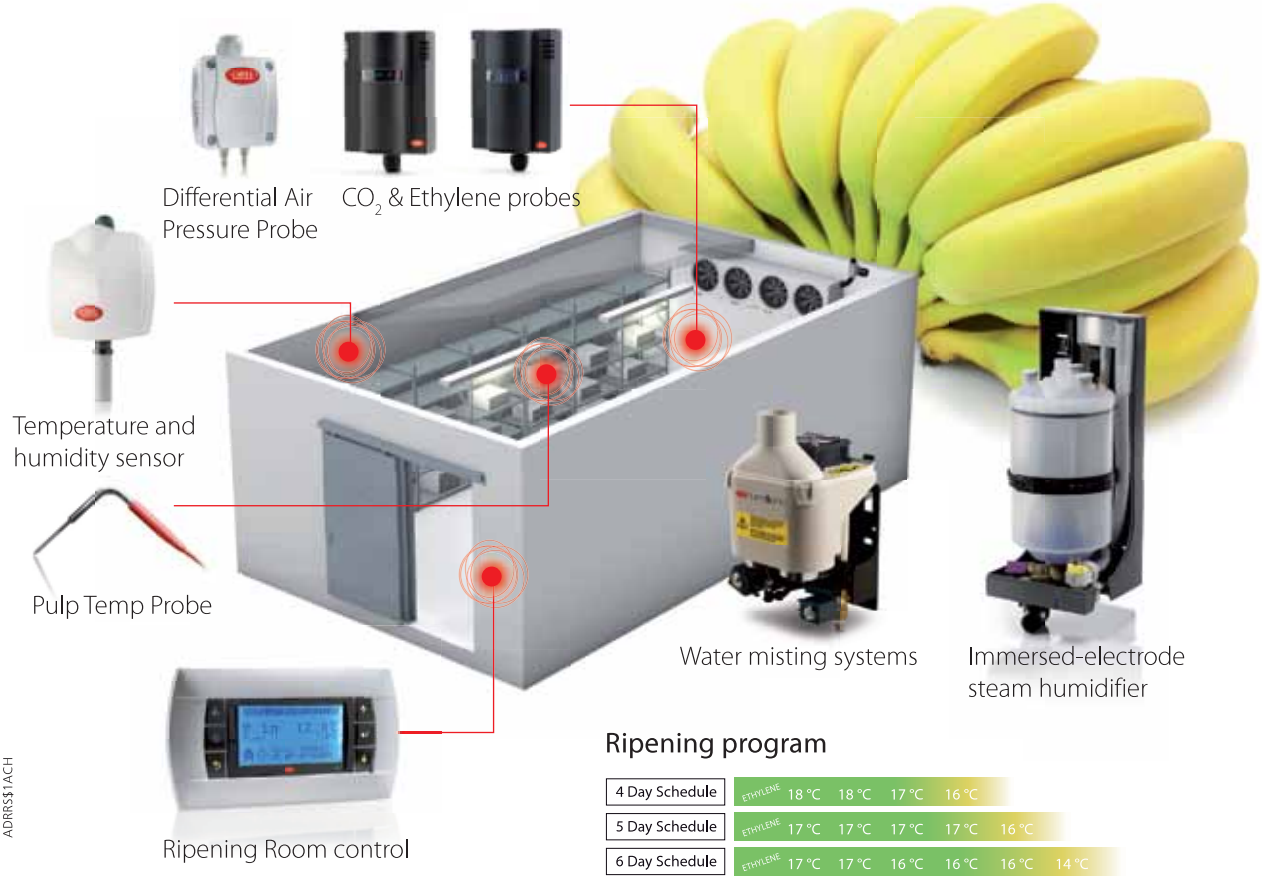

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5 Day Schedule	ETHYLENE	17 °C	17 °C	17 °C	17 °C	16 °C		
6 Day Schedule	ETHYLENE	17 °C	17 °C	16 °C	16 °C	16 °C	14 °C	
7 Day Schedule	ETHYLENE	16 °C	16 °C	16 °C	16 °C	16 °C	14 °C	14 °C
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Editorial

New Innovative Cooling Technology is the Need

Solar air conditioning sounds like a way to save money while keeping cool. For finding a way to keep the systems running at night, a hybrid model could be used. Currently, large commercial models are in testing and residential models are expected to follow. Similarly, Magnetic refrigeration is not a new idea. Ever since German physicist Emil Warburg observed in the 1880s that certain materials changed temperature when exposed to a changing magnetic field and studies opine this magnetocaloric effect technique can be used to attain extremely low temperatures, as well as the ranges used in common refrigerators.

The material that simultaneously reflects light and radiates heat at frequencies that vent it through the Earth's atmosphere could one day help cool buildings on hot days. The material cools itself to a temperature below the ambient air, and has been tested on a rooftop at Stanford University by its inventors, who are now working on scaling up the design. Peltier technology opens new opportunities for special applications. It has only begun to be used more recently in refrigerated laboratory incubators especially if the process does not require extensive temperature differential cooling or energy efficiency. Peltier elements absorb heat on one side and dissipate it on the other, inducing the current to act as a refrigerant in the cooling cycle.

Researchers say, a new super-thin material can cool buildings without needing electricity, by beaming heat directly into outer space. In addition the material could help reduce demand for electricity. This material is made of seven layers of silicon dioxide and hafnium dioxide on top of a thin layer of silver. The way each layer varies in thickness makes the material bend light in ways that grant it cooling properties.

For decades, researchers have been exploring to try to make systems that cool buildings more efficiently by radiating heat at night. In fact, black materials are very good at emitting heat means, they absorb a lot of sunlight. And of course, cooling with sound waves is a relatively new concept. While these designs are just beginning, still to be tested comprehensively, this could open the door to a new generation of energy efficient cooling systems. However, magnetic cooling is a new refrigeration technology with several advantages that combine to make it an environmentally friendly option.

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Tel.: (022) 2507 3300 / 01

Rs. 100/- Per Copy
Rs. 1000/- Annual Subscription

Printed by Pravita Iyer and Published by Pravita Iyer on behalf of Chary Publications Pvt Ltd., and Printed at PRINT TECH, C-18, Royal Indl Estate, Naigaum Cross Road, Wadala, Mumbai 400 031 and Published at 311, Raikar Chambers, Govandi (East), Mumbai 400 088.

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Ziehl-Abegg wins international business award

The Künzelsau-based firm of Ziehl-Abegg has won an accolade at GlobalConnect. "The fact that the GlobalConnect Award is presented by industry for industry is what makes this prize so special" said Dr. Nils Schmid, Deputy Prime Minister and Minister of Trade and Finance for the State of Baden-Württemberg on presenting the award. Ziehl-Abegg SE received the GlobalConnect Award in der "Global Player" category". The State of Baden-Württemberg, the Baden-Württemberg Chambers of Trade and Industry, Handwerk International Baden-Württemberg, Baden-Württemberg International and the Messe Stuttgart honour outstanding entrepreneurial achievements in the areas of exports and internationalisation. Export Director Thomas Brommer accepted the award from Minister Schmid during a festive gala event in the Landesmesse. Ziehl-Abegg manufactures fans and motors, as well as the associated control systems. Air-conditioning systems in hotels, refrigerated counters in supermarkets and ventilation systems in trade fair halls are just a few examples of where Ziehl-Abegg products are in service. Minister Schmid paid special emphasis to this in his presentation speech, "With its motors, fans and control systems Ziehl-Abegg has carved out an international reputation for itself and is a market leader in key areas including, amongst others, elevator drives. However, there is also a global demand for products bearing the 'Made in Künzelsau' label for use in ventilation technology, e.g. in air-conditioning systems for large building and industrial complexes." The aim of this event, held every two years, is to provide information for medium-sized enterprises on key export markets and strategies and to help them becoming an exporter. At the exhibition, 250 experts from the sector pass on their knowledge and experience in exporting and internationalisation to the more than 3,000 visitors. ■

Tecogen sells two Ultra InVerde CHP Systems to award winning Nursing and Rehabilitation Center

Tecogen Inc. announced sale of two INV-100 Ultra InVerde combined heat and power (CHP) units to a Brooklyn-based Award Winning Nursing and Rehabilitation Center. The units will be an upgrade for a unit destroyed by Hurricane Sandy. The InVerde system will provide space heat and hot water; electricity and air conditioning. The air conditioning is provided by the InVerde powering a steam fired boiler. The Tecogen unit is expected to save the nursing and rehabilitation center approximately $90K a year in energy costs. In addition to cost savings, the Tecogen system provides the building with emergency stand-by power when grid power is lost. This feature keeps the building's lights on and elevators working during outages like those experienced in the aftermath of Hurricane Sandy. In addition to significantly reducing energy costs, the system cuts criteria pollutants, the compounds contributing to smog. "Beyond the cost savings of cogeneration, the Tecogen unit provides the nursing home with the reliability of on-site power generation," said Robert Panora, President and COO of Tecogen. "Loss of power is dangerous in many situations, but more so in a health care facility." ■

AHRI launches two New Certification Programs

The Air-Conditioning, Heating, & Refrigeration Institute (AHRI) announced two new certification programs: Central Station Air-handling Unit Casings (AHUC) & Liquid-to-Liquid Brazed & Fusion Bonded Plate Heat Exchangers (LLBF). The two new programs join AHRI's 41 other programs, all of which verify the performance ratings for more than 40 product categories via random selection and annual testing at third-party laboratories.AHRI Standards 1350 (I-P) and 1351 (SI), Mechanical Performance Rating of Central Station Air-handling Unit Casings, are alrerady published and will serve as rating standards for new AHUC certification program. When paired with AHRI's existing Central Station Air-handling Unit Supply Fan, Forced Circulation Air-cooling & Air-heating Coils, and Air-to-Air Energy Recovery Ventilators certification programs, the new program can help ensure the overall performance of an air-handling unit. The AHUC program will verify casing deflection and casing air leakage and has the option of verifying thermal transmittance with leakage, thermal transmittance without leakage, & thermal bridging.Products tested in the LLBF certification program are rated to AHRI Standard 400, Liquid-to-Liquid Heat Exchangers, and applies to production models of brazed and fusion bonded plate-type heat exchangers with heat duty up to 16 million Btu/h and flow rates up to 1,200 GPM, utilizing water and/or sea water as fluids and utilized in heating, cooling, and district energy HVAC applications. As with its gasketed plate-type liquid-to-liquid heat exchanger program, AHRI will offer specification sheet verification for this program, providing an additional layer of performance reliability. "AHRI programs have served the heating, ventilation, air conditioning, refrigeration, and water heating industry for more than 50 years by independently verifying manufacturers' performance ratings for a variety of equipment."The AHRI Product Performance Certification Programs are voluntary programs, administered and governed by AHRI, which ensures that various types of HVACR, and water heating equipment perform according to manufacturers' published claims. ■

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Bry-Air to launch Adsorption Chillers

Bry-Air (Asia), headquartered in India and Power Partners, Inc. of Athens, GA, USA have signed a license agreement for Bry-Air (Asia) to manufacture and sell Power Partners' ECO-MAX brand Adsorption Chillers in India and other markets. This agreement means that Bry-Air (Asia) can further expand its broad product portfolio to include closed-loop adsorption products. Under the agreement, Power Partners will share its extensive knowledge of adsorption chiller design, manufacturing, applications and marketing with Bry-Air (Asia) and assist with product commercialization. "Adsorption chillers use energy from waste heat, with very low electricity consumption, to provide chilled water for process cooling and air conditioning, & they do this with "green" refrigerant (water) & desiccant (silica gel). We are excited about the opportunities for revenue growth and innovation that this agreement provides," said Deepak Pahwa, Managing Director, Bry-Air (Asia). ■

Johnson Controls' Technology and Consulting Expertise helps China Office Tower achieve Double Green Certification

Johnson Controls, a global multi-industrial company, used its building technology and consulting expertise to help an 850,000 sq ft office tower in Changsha City, China earn two prestigious green building certifications & cut energy consumption by 28%. The Northstar Delta Office Tower is the first in the region, awarded two green building certifications including the Leadership in Energy and Environmental Design (LEED) certification by the U.S. Green Building Council (USGBC), that provides third-party verification to confirm a building is operating at the highest levels of efficiency and sustainability. The second certification was the Green Building Evaluation Label, a program managed by the Chinese government that evaluates projects to make sure they conform to standards set for green building."We turned to Johnson Controls because of its expertise and long-term leadership in building solutions and green certification," said Min Zhang, DGM and chief architect of the Northstar Delta Office Tower. "Johnson Controls' recommendations included an innovative heat recovery system to harness waste heat. ■

Sporlan Division of Parker Hannifin celebrates opening of its new Training Center in Washington

Sporlan Division of Parker Hannifin Corporation, recognized as a leading manufacturer of HVAC/R components announced the opening of their new state-of-[the-art refrigeration system training center. The new training center is designed to facilitate technical training on today's modern refrigeration systems by offering both classroom and hands on activities. Sporlan's knowledgeable staff consists of product managers, sales engineers, design engineers, and technicians. Sporlan offers a Specialist program, an extensive 3-day course in the new training center that includes tours of the manufacturing and test lab facilities, as well as product selection, application, teardown, rebuild and refrigeration system troubleshooting. "Sporlan has a rich history of training the HVAC/R industry since our inception in 1934. Our training focuses on refrigeration system applications and troubleshooting for service technicians, distribution channel partners, and original equipment manufacturers. We have expanded our training to reach more of the industry by offering ChillSkills online courses, an updated 1 day Supermarket Systems Training, and the advanced 3 day Sporlan Specialist Program. ■

Carrier Transicold Supra units selected for Tesco's First Drawbar Reefer

Tesco, the largest retailer in the UK and one of the largest in the world, has introduced its first temperature-controlled drawbar vehicle, fitted with Carrier Transicold Supra truck refrigeration technology to help improve the efficiency of express store deliveries. Carrier Transicold, which operates in the UK as Carrier Transicold UK, helps improve global transport and shipping temperature control with a complete line of equipment for refrigerated trucks, trailers and containers, and is a part of UTC Building & Industrial Systems, a unit of United Technologies Corp. Tesco's express stores typically are located in residential or built-up areas, making it difficult for tractor units with 13.6-metre trailers to deliver. The flexibility of an 18.75 metre drawbar combination vehicle means the truck can now reach express stores more easily and with a larger payload than a rigid truck operating alone – resulting in reduced road miles. The drawbar's manoeuvrable design also has the capacity to carry 48 standard roll cages – an additional three compared with a standard 13.6m trailer. The drawbar vehicle, designed by Wheelbase Engineering, is fitted with Carrier Transicold's Supra 1150U MT (multi-temperature) undermount unit. It features two remote evaporators recessed into the trailer's ceiling to ensure a safe walk-through environment for operators. The forward compartment relies on a Supra 850 MT unit to maintain the set point inside its Solomon bodywork, selected for its robust design and proven reliability."Continually improving the efficiency of our fleet is a key focus for the business, and with the help of Carrier Transicold UK we've been able to come up with a solution that really hits the mark," said a spokesperson for Tesco. "We have enjoyed a long and successful relationship with the team at Carrier. We specify their reefer units as they are so well suited to our operating needs."Carrier Transicold's Supra range speeds and ensures accurate temperature control for all chilled and frozen cargoes. ■

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LG unveils first Mega-Capacity Refrigerator with Double Door-in-Door at CES 2015

LG Electronics (LG) introduces its first double Door-in-Door Mega-Capacity refrigerator in 2015. The award-winning "door-in-door" concept pioneered by LG is among the highlights of cutting-edge refrigerator innovations unveiled at the 2015 International CES in Las Vegas. This new model, which is expected to be ENERGY STAR® certified, has two independent Door-in-Door compartments, giving you the ultimate in convenience - better organization & easy access - while maximizing conservation of cold air. The right Door-in-Door is accessible from both the outside with a simple push of a button as well as from the inside, making it easy to load with often-used items like snacks, drinks, lunches & more. The left Door-in-Door provides additional easy access storage space via a trigger on the bottom of the door. By utilizing LG's innovative Door-in-Door feature without opening the entire refrigerator, cold air loss is reduced by up to 47% to help keep food fresh longer. The refrigerator also features contour processed, tempered glass that has been applied over curved glass. Black patterned finishing provides a stylish design that is both aesthetically pleasing and leaves the outside fingerprint and smudge resistant so it always looks its best. The refrigerator is also equipped with EasyLift Bins, which allows users to adjust the height of the internal compartments to accommodate large or oddly-shaped bottles. "Our Door-in-Door has been without a doubt one of the most popular design features we've ever introduced," said David VanderWaal, head of marketing for LG Electronics USA. "With the introduction of the new Mega-Capacity Door-in-Door, we've taken this popular feature and created an even better refrigerator. Organizing food takes on a whole new level of satisfaction with this model." The LG Mega-Capacity Door-in-Door refrigerator also offers Smart Diagnosis, which allows call center representatives to quickly diagnose problems over the phone. LG's Smart Diagnosis smartphone app 2 even allows home owners to record and analyze signals from the refrigerator for immediate advice on repair options. Specifications include: 34 cubic feet of space; Double Door-in-Door; Smart Cooling Plus; Fresh Air Filter; Smart Diagnosis; Contour Glass Finish. ■

STULZ Showroom wins Iconic Award 2014

The showroom of air conditioning specialist STULZ received the honor Winner at the Iconic Awards 2014 in the category "Architecture/Retail" for its unusual presentation concept. The German Design Council was particularly impressed by the fusion of production, storage & sales, which produced a great communicative effect. The 200 sq mtr "Under Construction" presentation concept was developed by MIKS brand space design agency for showroom of STULZ's new Sales and Customer Center. Although planned as a temporary installation, the exhibition has now become a permanent part of the reception lounge. In October, the showroom was rewarded as Winner at Iconic Awards 2014 in the 'Architecture/Retail' category. The jury of German Design Foundation praised unusual design and the communicative effect achieved. Prize means, STULZ showroom automatically receives a nomination for German Design Award 2015 in the category "Excellent Communications Design – Interior Design". This prize will be awarded by a jury of the German Design Council in February 2015. ■

2015 Regional Standards and Effects on HVAC Industry highlighted in ASHRAE Session

The new year ushered in new regional federal efficiency standards for residential split system and packaged central air conditioners. Guidance on how to meet those standards will be shared during a free session at ASHRAE's 2015 Winter Conference, Jan. 24-28, Chicago. The rationale for these standards is that the United States climate varies enormously; higher standards that save money in Mobile may not save as much in Minneapolis. Regional standards ensure that we can get as much cost-effective efficiency as possible, evaluating the cost effectiveness more appropriately for different locales. The standards took effect January 1, 2015. Speakers will discuss these new standards during the free AHR Expo Session, New 2015 Regional Standards and the Effects on Different Areas of the HVAC Industry, which takes place on Jan. 26, at the AHR Expo. In January 2010, manufacturers represented by the Air-Conditioning, Heating and Refrigeration Institute (AHRI) reached a consensus with efficiency advocates on a proposal to adopt regional standards. Through negotiation with other parts of the HVAC&R industry, a draft standard was developed with different required efficiencies for air conditioning using split system and packaged air conditioners in each of three geographic regions. For the first time, federal regulations are based on installation date as well as date of manufacture, so new regional standards affect what distributors and contractors can sell and what consumers can purchase. The Expo Session explores the new rule from the perspectives of experts involved in its origin, evolution and implementation. Harvey Sachs, American Council for an Energy-Efficient Economy, will outline the responsibilities of all parties as a result of the Negotiated Rulemaking on Enforcement of Regional Standards in summer 2014, which is being codified by DOE. The new Rule, coupled with a revised FTC "Yellow Label," should give the best possible outcome for all parties trying to achieve efficiency and do business. The Conference takes place at the Palmer House Hilton, while the ASHRAE co-sponsored AHR Expo is being held from Jan. 26-28 at McCormick Place. ■

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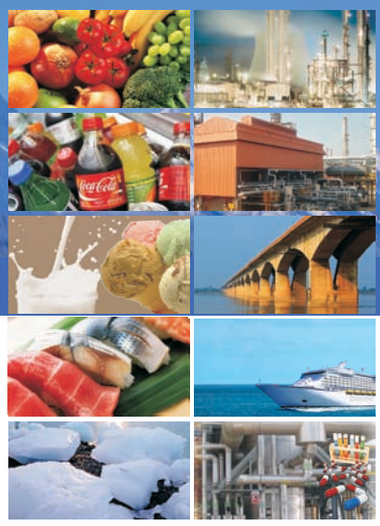

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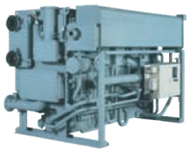
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Increase in ozone-destroying substances, but Montreal Protocol on track

Research from the University of Leeds and an international team of scientists has shown a recent increase in atmospheric hydrogen chloride (HCI), a substance linked to destruction of the ozone layer. It was anticipated that there would be a decline in HCI under the Montreal Protocol, the international treaty designed to protect the ozone layer by phasing out the production of ozone-depleting substances. Dr Emmanuel Mahieu from the University of Liège in Belgium, who led the research, explained, "It's important to say that the Montreal Protocol is still on track, and that this is a transient reversal in the decline of HCl, which can be explained through a change in atmospheric circulation, rather than rogue emissions of ozone-depleting substances." The study, published in the journal Nature, explains that the unexpected increase is caused by a temporary but prolonged anomaly in atmospheric circulation, changing the balance between chlorofluorocarbons (CFCs) and their breakdown product HCI. Professor Martyn Chipperfield from the University of Leeds, who led the modelling work for the study, said, "The expected deterioration of ozone-destroying chemicals in the atmosphere is certainly more complex than we had imagined. Rather than a steady decline, these findings have presented a rather more complicated picture. "Through comparison with detailed computer models, we have identified this decline as temporary due to changes in upper atmospheric wind patterns, so we remain optimistic that the ozone layer will recover during the second half of the century." The recent increase in HCl concentrations was only observed in the Northern Hemisphere, whilst in the Southern Hemisphere, HCI continues to decrease, as expected, in line with the Montreal Protocol. Professor Chipperfield added, "There are natural differences in the atmosphere between the Northern and Southern Hemispheres, due to the influence of the Earth's surface topography and slight variations in the Earth's orbit around the Sun during the year. While atmospheric chlorine levels remain high we may see cases of large ozone depletion, especially over the polar regions." The findings are based on measurements by a network with stations in Spitsbergen, Greenland, Sweden, Switzerland, Japan, Tenerife, Australia and New Zealand. These are backed up by satellite observations and model simulations. ■

EHPA reports European heat pump market is on the rise

The key finding of the recent heat pump statistics and market report published by the European Heat Pump Association is - the European heat pump market is on the rise. The technology – being both energy efficient and renewable - can significantly contribute to the goals of the European Energy Union. EHPA has published the latest version of its European Heat Pump Market and Statistics Report 2014, the most comprehensive study compiling market data and statistics on heat pumps from 21 European countries. Report also presents latest technology and industry trends, gives an overview of the European policies affecting heat pumps and analyses the technologies contribution to energy efficiency, renewable energy use and greenhouse gas emission reduction. The report reveals that after 3 years of stagnation and a slight decline, the markets are recovering. 771 245 heat pump units were sold in Europe in 2013, an increase by 3% and early data for 2014 showed this trend to continue. Thomas Nowak, Secretary general of EHPA believes this is very encouraging news, not only for the heat pump sector but also for Europe's broader policy goals. ■

Honeywell starts full-scale Production of Low-Global-Warming propellant, Insulating agent and Refrigerant

Honeywell has started full-scale commercial production of low-global warming potential material used as an aerosol propellant, insulating agent and refrigerant. The material, known by the industry designation HFO-1234ze and marketed by Honeywell under its Solstice® line of low-global-warming materials, is being produced at the Honeywell Fluorine Products facility in Baton Rouge, La."Honeywell's Baton Rouge production facility is ready to serve customers around the world with this innovative material, which has an ultra-low GWP of less than 1," said Ken Gayer, vice president and general manager of Honeywell's Fluorine Products business. "We are seeing increasing demand for our entire Solstice line of low GWP materials, and this new product has already been adopted by a range of customers globally."Honeywell's Baton Rouge facility was built in 1945 and continues to serve as one of Honeywell's main manufacturing sites for its Performance Materials and Technologies business. Louisiana Governor Bobby Jindal said, "Honeywell helps support hundreds of jobs in our state, and we're proud the company is expanding in Baton Rouge with a brand new product line. This project is a good example of how Louisiana's outstanding business climate is convincing companies like Honeywell to reinvest in our state, retain great existing jobs and create additional new career opportunities for our people."In September 2014, at an event sponsored by the White House, Honeywell announced that it will increase production of its low GWP refrigerants, insulation materials, aerosols and solvents, and, prior to 2020, will drive a 50 percent reduction in its annual production of high GWP hydrofluorocarbons (HFCs) on a CO_2 equivalent basis. The company projects that use of its low GWP Solstice materials to replace HFCs will eliminate more than 350 million metric tons in CO_2 equivalents by 2025, equivalent to removing 70 million cars from the road for one year.HFO-1234ze is a next-generation material that is non-ozone-depleting, non-flammable per ASTM E681 and ISO 10156:2010 testing, and has a low-GWP of less than one. ■

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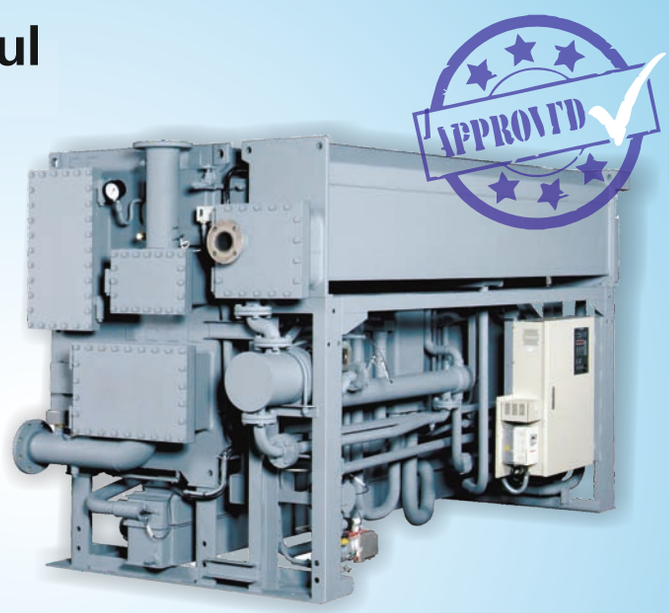

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Greenheck introduces large Dynamic Fire Dampers

Greenheck offers the largest, UL Listed, non-actuated, dynamic fire dampers in the industry. Four new dynamic fire damper models are available to protect oversized openings in buildings. Featuring a fabricated steel 3V blade type, Model DFD-210 has a maximum size of 128" x 100" with a 1.5-hour fire resistance rating; Model DFD-230 has a maximum size of 72" x 48" with a 3-hour fire resistance rating. Featuring fabricated steel airfoil blades, Model DFDAF-310 has a maximum size of 128" x 100" with a 1.5 hour fire resistance rating; Model DFDAF-330 has a maximum size of 120" x 96" with a 3 hour fire resistance rating.Greenheck, the worldwide leader in manufacturing and distributing air movement and control equipment, offers the most UL certified dampers and the largest selection of AMCA licensed dampers in the industry. ■

Non-Residential Air Conditioners Market in Europe 2015-2019

One major trend in the market is the Eurozone recovery. The market is steadily recovering from the adverse impact of the crisis and offers immense growth potential to vendors. New entrants are attracted to the market and the industry is returning to its pre-crisis state. According to the report, one of the key factors driving this market is the increase in construction activities. The increase in the construction of commercial buildings influences the sales of non-residential air conditioners in Europe.Further, the report states that low product differentiation curtails vendors from charging a premium price. As a result, there is intense competition among established vendors to maintain profitability, while the ROI cycle for new vendors is prolonged. Foreign players are diversified, having global resources to provide chillers tailored to the needs of customers.The study was conducted using an objective combination of primary and secondary information including inputs from key participants in the industry. The report contains a comprehensive market and vendor landscape in addition to a SWOT analysis of the key vendors.■

Mitsubishi Electric US Cooling & Heating Division HQ earns two Green Globes

Mitsubishi Electric US, Inc. Cooling and Heating Division, America's No. 1 selling brand of ductless cooling and heating systems, announced its headquarters in Suwanee, Georgia, has earned two Green Globes from the Green Building Initiative (GBI). The Green Globes certification demonstrates "excellent progress in the reduction of environmental impacts and use of environmental efficiency practices." "We are proud to achieve Green Globes certification for our Suwanee office," said Gary Nettinger, director, OEM solutions & applications, Mitsubishi Electric US, Inc. Cooling & Heating Division. "This accomplishment illustrates our significant commitment to sustainability and efficiency when approaching the design and construction of our facility." The Mitsubishi Electric offices are equipped with the manufacturer's own VRF zoning systems, which contributed to its high ratings in the Energy and Indoor Environment assessment areas. Mitsubishi Electric's headquarters, and built by Industrial Developments International (IDI), Atlanta, with the Green Globes assessment and rating system in mind. ■

North American Air Compressor Market is expected to reach $6.6 Billion by 2020

According to a report titled "North American Air Compressor Market (Type, Technology, Lubrication Type & Countries) - North America Opportunity Analysis and Forecast - 2013 - 2020", by Allied Market Research, the North American air compressor market is forecast to reach $6.6 billion by 2020, growing at a CAGR of 6.1% during 2014 -2020. The North American market highlights potential of centrifugal air compressors which currently represent around 15% of the total market size by value. By 2020, the centrifugal air compressor market is expected to double of its current size, representing over 30% of the total market size by value. The need of pure air in applications in FMCG, medical and pharmaceutical industries would increase adoption of oil-free air compressors, which is expected to generate over 46% of market size by value by 2020. The North American market, is recovering due to the reinitiating of the stalled projects since 2012 onwards. Among lubrication methods, oil lubrication is commonly adopted in the North American market. The oil lubricated air compressors contributed more than ½ of the market size by value in 2013. The air compressor systems are stationary and portable models. The stationary air compressors were major revenue contributors in 2013 and would continue to drive the market through 2020, based on their wide applications in heavy duty industry. The portable air compressors are useful in on-site construction applications, FMCG industry and medical & pharmaceutical purposes. Conclusively, applications of air compressors are observed in industries such as FMCG, oil & gas, manufacturing, automotive, etc., due to energy efficiency, eco-friendliness and portability of these machines. The increased oil exploration activities in USA and Mexican territories are driving the usage of heavy duty air compressors in the region. DeepResearchReports.com adds 2015 Deep Research Report on Global Plate-fin Heat Exchanger Industry of 151 pages to the machines and equipment market intelligence & research collection of its online library. ■

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Transcritical CO_2 Refrigeration & Heat Pump Technologies

Potential applications of transcritical CO_2 vapor compression refrigeration technologies in India are supermarket refrigeration and simultaneous cooling and heating in food industries

Over the last two decades, the refrigeration, air conditioning & heat pump industry has been forced through major changes caused by restrictions on refrigerants. Although CO_2 (R-744) was widely used as refrigerant in the early 20th century, its use disappeared from around 1940 with the advent of the fluorocarbon chemicals. However, increasing focus on environmental issues (Montreal & Kyoto Protocols) of fluorocarbon chemicals created a strong interest in systems using natural fluids in general, and CO_2 in particular due to its non-flammability & non-toxicity (Fig. 1). The modern CO_2 refrigeration cycle was developed in 1988–1991 by the Norwegian professor G. Lorentzen (1915–1995) & his team. Other principal benefits of CO_2 are that it is a natural substance; it is cheap, readily available, not poisonous

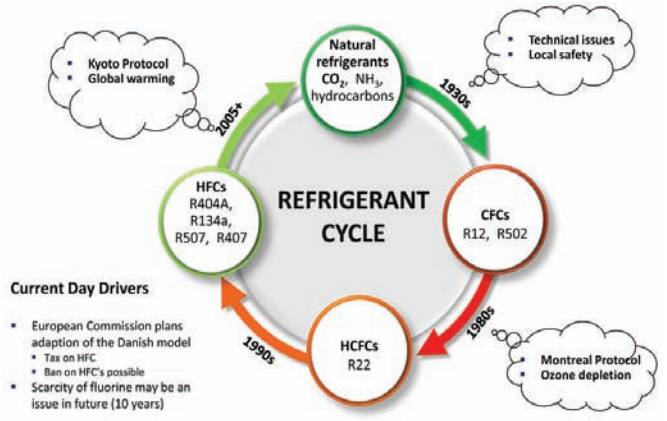

Fig. 1: The closed refrigeration cycle Driving CO_2 system

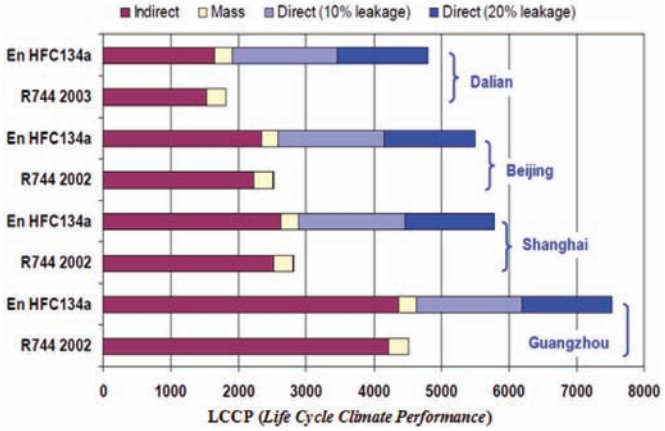

Fig. 2: LCCP comparison of CO_2 and R34a for mobile air-conditioning

in any common concentration, and nonflammable. At prices a bit over $1 per pound (for purity up to 99.9%), it is truly an inexpensive refrigerant. Many recent studies showed that CO_2 has very little effect on environment compared to presently used refrigerants (Fig. 2). Within last decade, many prototypes have developed by institutions as well as industries. In this article, I will share some information related to R&D activities and commercial products on CO_2 system, which may be useful for researchers and manufacturers in India.

Recent R&D progress

A basic transcritical CO_2 vapor compression refrigeration system consists of evaporator, compressor, gas cooler and expansion device. The main difference between this cycle and conventional cycle is that unlike to condenser, the heat rejection in gas cooler takes place at supercritical regimes. This gives an opportunity to optimize heat rejection (gas cooler) pressure leading to maximum cooling or heating COP and the knowledge of the optimum operating conditions corresponding to maximum COP is a very important factor in the design and operation. There are three fundamentally different ways of controlling pressure:

- Varying the refrigerant charge in the high side of the circuit,
- Varying the inside volume of the high-side.
- Allowing the refrigerant temperature to control pressure.

While the first two options give possibilities for active pressure control, the last method is actually a passive scheme where the refrigerant charge/volume conditions are adapted to give the desired change in pressure when temperature varies. Hence, it needs to developed proper technologies for high pressure regulation at optimum level. Another important issue is the low COP of the system. Hence, the recent R&D activities can be divided into major heads:

- System performance improvement,
- Optimum high side pressure control
- Application oriented developments.

Many cycle modifications have been proposed recently for the performance improvements of the transcritical CO_2 system, including staging of compression and expansion, splitting of flows, use of internal heat exchange, and work-generating expansion instead of throttling, parallel compression, ejector and vortex tube. However, the maximum efforts have been given for ejector expansion system and large number of research and development activities has been performed within last decade related to ejector design, modeling, optimization and operation. One very interesting advantage of ejector is the simultaneous control of ejector entrainment ratio and system high side pressure may be possible.

Within last decade large R&D activities have been performed, and many research papers and patents have been published on optimum high pressure control of CO_2 refrigeration and heat pump systems. Major development are related to real time optimization and control, many statistical techniques also have been used such as artificial neural network identification technique and particle swarm optimization technique. Basic concept of controlling the gas cooler pressure at optimum level is the simultaneous control of the mass flow rate and expansion valve opening. The mass flow rate can be change by using variable speed compressor (using stepper motor) or by using receiver for charging and accumulation of CO_2. The expansion valve opening can be regulated by electrically operated step motor. Proportionale Integral-Derivative (PID) control technique and Programmable Logic Controller (PLC) can be used for this. The target parameter may the maximum COP or minimum compressor work for given cooling or heating load. Hence the overall high side pressure control consists of three steps: data sensing and accumulation, optimization and operation control.

The initial researches and developments on transcritical CO_2 vapor compression cycle were started with mobile air-

Dr J Sarkar, Senior Assistant Professor, Department of Mechanical Engineering, Indian Institute of Technology, Varanasi, India is MTech. and PhD from IIT Kharagpur has published about 90 research articles. His Biography is included in Who's Who in the World 2010 and is Editorial Board Member of six International Journals.

conditioning and heat pump water heater. After that, various application areas have been identified and prototypes have been developed. Following are the major application areas in which R&D activities have been carried out:

- Mobile air-conditioning (cooling & heating; mainly cars, but also include bas and truck).
- Space air conditioning (include cooling, heat and both; windows as well as rooftop).
- Heat pump water heater (commercially available) and water cooler.
- Light-commercial refrigeration systems, chiller for beverages foods.
- Supermarket Refrigeration Systems (may be for both refrigeration and heating: Fig. 3).
- Simultaneous cooling and heating applicable to drying and food processing.
- Environmental control units.
- Mini and micro refrigeration.

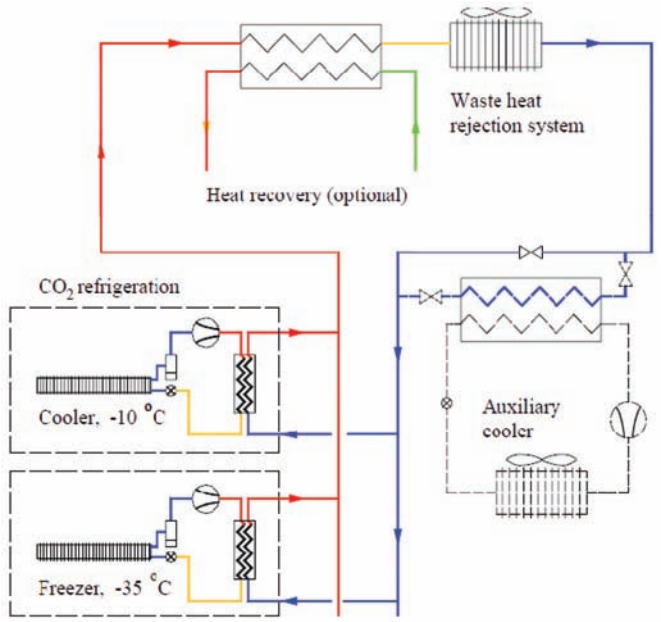

Fig. 3: Decentralized CO_2 supermarket refrigeration system

Commercialization issues

Denso of Japan had commercialized the heat pump water heater (EcoCute) in 2000s and large numbers of products have been already sold. Mobile air-conditioning is available in USA and Europe markets. Some manufacturers of transcritical CO_2 systems and its components are listed in Tables 1 and 2. The CO_2 refrigeration system has been already installed worldwide in supermarket and India has also identified as a potential user. Presently in India, installation of CO_2 system is not difficult, because all the components such as compressor, evaporator, gas cooler, valves are easily available in open market and sales offices of some global providers are also there in India. However, retrofit of present products is not possible with CO_2 (properties are very much different), hence, new system have to developed and purchased from outside, which may be the costly options.

Transcritical CO_2 systems	Manufacturers
Mobile air-conditioning	Denso (Japan), Visteon (Europe), Konvekta (Germany)
Water heater	Denso (Japan), MYCOM Mayekaw (Japan)
Space air-conditioning	Green & Cool (Sweden), Star Corporation
Commercial refrigeration system	Cerrier, Danfoss (Denmark), Cowley Services (New Zealand), Kuldeteknisk (Norway)
Industrial refrigeration system	Carnot Refrigeration (Canada), Carel (Italy)
Supermarket refrigeration system	Carnot Refrigeration (Canada), Heatcraft Refrigeration (USA), Hillphoenix (USA), Alfa Laval (Sweden)

Table 1: Commercial products of transcritical CO_2 systems

Manufacturers	Transcritical CO_2 system components
Dorin (Italy)	Semiharmetic compressor
Bitzer (Germany)	Semihermetic compressor
Bock (Germany)	Hermetic compressor
Danfoss (Denmark)	Tubes, valve, pressure gauge, heat exchanger
Denso (Japan)	Open-type compressor
Sanyo (Japan)	Hermetic compressor
Carly (France)	Mufflers, oil separators, valves, Filter drier, liquid receiver, sight glasses, valves, Suction accumulators
EcoThermics Corporation (USA)	Axial compressor
Alfa laval (Sweden)	Brazed plate heat exchanger
Emerson Climate Technologies	electronic controllers, expansion valves, system protectors
Henry Technologies (UK)	High pressure relief valve

Table 2: Manufacturers of transcritical CO_2 system components

Conclusions

Present R&D activities have identified CO_2 as a future refrigerant along with hydrocarbons in various cooling and heating equipments. India also has great opportunity to use CO_2 as a refrigerant for various applications particularly in simultaneous cooling and heating (useful in food industries). Technologies are available, however, the main challenges may be related to policy and economics. ■

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Lean Management at Gubba Cold Storage

We at Gubba have always been on the forefront of technology, processes and systems in terms of our operation. We have developed internally our own software application for managing the entire operations – truck loading/unloading, storage and invoicing.

We have benchmarked and put in the best safety practices, inventory management, pest control and plant & equipment operations and maintenance. Having done all these, we were on the lookout to see what more we could do to add value to our customers while improving our own business and profitability.

Then one of our associates introduced us to the philosophy of lean manufacturing and how implementing lean had dramatically changed their business fortunes. We then contacted the reefered Lean Expert, a company called Kanzen Institute, and initiated the process of lean implementation with them. Right at the start, the goals for lean implementation were fixed considering the key business indicators:

- Maximum utilization of cubic space – this has a direct impact on the business profitability since the main cost is the refrigeration.
- Minimum truck Turn Around Time – inward and outward – this enhances customer satisfaction.
- Maximize productivity of workers - labour cost being a significant component for both Gubba and the clients.

Gubba Prashanth, MBA, heads technical department of Gubba Cold Storage. He designed first state-of-the-art world class cold storage for seeds. He also heads marketing of Gubba and is instrumental in making Gubba from a 0.7 million cubic feet to India's Biggest 8 million cubic feet Company. He has been one of the 13 people from Indian refrigeration Industry selected by U.S. Trade & Development agency for a reverse Trade Mission.

The above goals were in line with the core lean philosophy which is "Doing more and more with less & less."

The lean implementation was done through a series of focused improvement workshops during which cross functional teams were formed to take up specific improvement projects across the various plants.

We have three broad types of plants – conventional seed storage, racked seed storage and frozen foods. One plant of each type was selected and teams were formed to focus on the flow of material from truck to storage as well as on the space utilization within the storage facility.

Lean Focused Improvement Workshop

On the first day, the lean expert gave the teams a basic orientation on how to observe the process under Lean paradigms in order to identify Muda (waste or non value added), Muri (strain) and Mura (inconsistencies / variations). The teams then spent the day observing the process and came out with a list of observations and opportunities for improvement therein. These were shared in the evening with the rest of the teams and the Gubba Management and actionable points were decided.

These actions were then implemented on the second day – they included change in practices or methods of doing work, some modifications in equipment/ tools to help workflow and reduce strain and some strategic decisions on how the process should be run.

On the third day, the same process was observed to verify and validate the impact of changes made and results measured. A 15 day action plan was made to complete the balance action items and these were monitored on a daily basis at the plant level and a weekly basis at the management level.

Truck Turnaround Time

The team members observed the truck loading and unloading activities from the paradigm of Zero Waiting time of truck. By definition loading means that material is being physically placed in the truck and unloading means material is being lifted out of the truck. Hence if at any point in time this is not happening, it means the truck is waiting. The entire process from Gate in to Gate Out was studied as the time taken for this is the overall time the truck is held up at Gubba. Some of the major

Lean Workshop under progress under leadership of Lean Expert Ganesh Mahadevan

Space Utilisation increased after increasing the height of the crates

improvements done by the team following the observations were:

- Synchronization of activities at docking area with the activities at the storage bays so that the bags flow smoothly through the lift, conveyor and manually.
- In several cases, some material had to be moved especially in racked storage facility to access the required material thereby delaying the start of loading. So a method of internal shifting prior to arrival of truck was implemented.
- Linked to the above, a system of Pre-Alerts was started wherein our Gubba Plant Supervisor would interact with the regular clients on the previous evening and get the details of the trucks expected on the next day. This helped in planning of labour, equipment & internal shifting.
- Delay in picking and removing SKUs in the frozen foods storage facility – multiple handling and counting of these products was observed. The team rearranged the entire ice cream room using 5S principles – any item should be located and picked in less than 30 seconds. A trolley was designed and put into use to minimize rough handling of crates.
- Muliple counting, cross checking and documentation was delaying the post loading process of gate pass generation. This was streamlined and a system having software and printer was shifted to the ante room next to the docking so that by the time the truck driver closes his vehicle and secures the goods the gate pass is ready.

Through all these improvements the average TAT for a 10 ton truck was drastically reduced from 45 minutes to 35 minutes. The labour productivity also went up significantly as the people were involved mostly in the actual loading/unloading activity and idle waiting time was cut out.

Storage Space Utilization

These teams worked with the paradigm "Chilling is meant for the client's material be it seeds, ice cream, dairy products or others". So any space in the facility occupied by other things or lying empty is non value adding from our perspective. This means we are spending money on refrigerating unwanted items or simply cooling empty space. Some of the major improvements done by the team following the observations were:

- Uneven height of seed bag Thappis observed resulting in unutilized space at the top. Maximum height marking and painting done on all bays to guide the hamali labour in filling up the bays.
- A racked slot can take upto 1.5 MT load, we observed that our average load ratio was about 1.3 MT which mean about 13% underutilization. The main reason for this was difficulty in stacking the regular bags on the pallet especially for bulky seeds like cotton. After discussing with our clients, we made the transition to bulk of the materials coming in jumbo bags of 1.5 MT capacity and these were loaded in the racked slots. Pallets and bags above 1.5 MT were also received and stored on the ground level.
- In the frozen foods facility we store a wide variety of products with varying packaging and sizes – carton boxes, crates, plastic packets etc. Here the team worked on fixing the stacking norms for each product based on client recommendations, the same was displayed and workers trained to follow them.

Within a couple of months of implementing these improvements, we had shut down one cold room in frozen food unit saving huge costs of refrigeration, increased our racked storage to 1.5 MT/slot & space utilization in conventional seed storage by 10%.

Sustenance of Lean Implementation

Our experience with this lean implementation was initially mixed. The focused improvement workshops brought our diverse employee base together promoting teamwork and sense of achievement which left everyone on a high at the end of the 3 days. But the hard part was to complete the action points and sustain the practices in the subsequent period. Here we, the top management have a significant role to play in terms of motivating and supporting the employees, monitoring their progress regularly and if need be even putting some pressure on them to finish things.

Over the last few months we have sustained about 60% of what we implemented which we are now in the process of enhancing. This we are doing through framing and implementation of Standard Operating Procedures (SOPs) which will incorporate all the good practices implemented during the lean improvement phase. We are also implementing a reward and recognition scheme for our employees wherein the best improvement ideas implemented will be appreciated in various forum like our newsletter, on the notice boards & in internal forums.

In conclusion, I would like to say that before Lean we thought, we are already the best and nothing is left to improve. But Lean opened up a different paradigm & this in turn gave rise to a whole new set of improvement opportunities. ■

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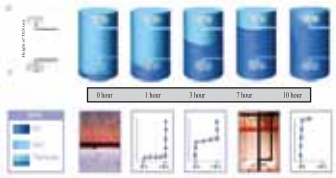

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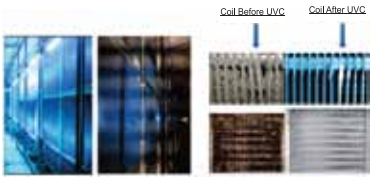

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BITZER is the largest suppliers of Refrigeration Package Systems in India

***Rob De Bruyn,** Managing Director, Bitzer, in an exclusive interview with **Cooling India** says, when a customer comes to BITZER, he is assured that he gets original parts.*

How do you find the expansion of Bitzer Compressor in India? And what are your future plans with regards to the same?

We have been growing since 2007 when we incorporated the business in India. And our expansion has been very well with two digit expansion each year and now we have got four Green Point Service Centre around the country. We have technical sales guys all around the country and we also have got brand centre in Delhi and this brand centre was developed so that many of the Northern Customers from far reach of Northern India could access our products and gain first hand in-depth knowledge of BITZER products that we have to offer in India. So the development of the business continues to go well.

In the next year, we will be heavily focusing on the Cold Chain Industry. The Government is also providing very good subsidies for logistics, cold chain supplies and we will follow the market as well.

Ammonia is another big area where we see some big potential for us in the coming years. Changes in the global refrigerants market has started taking hold also in India. We believe, the Ammonia as a Natural Refrigerant again will take a new role and a new place to take position in the market place.

Why would you think that Ammonia Refrigeration would take place in India Market and what are the changes that are coming across?

Well! Because in a first instance ammonia is well known in India, India has got one of the largest refrigeration Industries in the world. I think with the advent of new technologies like electronic controls, new compressors technologies particularly BITZER is offering the market price. We see even the greatest efficiencies, small systems, small gas charges which make it safer.

So, I think the net concept in Ammonia is to go small and small rather than larger and larger, which of course places us right into the commercial hands of market place where BITZER is having a wide range of ammonia compressors since many years. It is expanding the range to a larger disbursement and also we are doing it in Europe. Our systems are becoming smaller with Ammonia. So there is plenty of opportunity in this country.

What are the opportunities that the government is giving to the large cold chain industries in India?

Well! Very heavy subsidies depending on the region and the need of the region. And I think with the subsidies its making easier for people to access funds and financial resources; to put in place the good and viable cold storage facilities. And I think this is what we needed in rural India, of course, to have those facilities in the place and the fund that we need to develop the industry.

Apart from Urban India, please tell us about the installations of compressors in rural India? What are the solutions you

have got for rural India? Do you have any partners or clients in rural India?

Many! Infact the BITZER is the largest suppliers of Refrigeration Package Systems in India. And, these systems are being divided between our partners. We got numbers of partners around the country which is trained by BITZER. They are trained for the correct information, knowledge, mutual understanding and methodology to install correctly and with a good service. So these partners are scattered all over the country. Our systems are varied invariably, we do screw systems, we do open drive reciprocrative systems and in some places of the country where power supply is still challenging, an open drive system can still be a very useful function. Arguably, it is not efficient but then, if we measure efficiency by serviceability then an open drive service in this challenging region is perhaps the most efficient service we could have. So, it really depends on regions, applications and of course the ability in equipment services and maintenance which is also very important. Of course in the city it is much more easier for the services and technicians but in some areas it is very difficult in remote areas and we overcome it by applying the correct systems so it might be a open drive or a less complicated systems where we consider less on the energy efficiency of the compressor and more on the serviceable life of the compressors. So we look at each job and we apply engineering challenge in its own way which is very important. BITZER has got such a wide range of products. We can apply different products with different applications and needs.

How would you describe BITZER compressors are very powerful under all working conditions?

The engineering behind BITZER is such that operation envelope is very wide. This is being by the engineering excellence; the machines. In 93 years of building compressors, BITZER is the old established European company. So we have been able to refine and optimize our systems over gone by years and to adapt to the conditions we find, and in India there are very harsh conditions in some cases. This is one of the reasons why BITZER has performed very well in complicated conditions of India. Very important is that the Green Point Service Centres are available and accessed from all the four corners of the country. So, I think that all of these ensure that the customer of BITZER can have a good service with its many years of experience.

Could you share something on the GREEN POINT that BITZER has started & specific selection of geographical location for the same?

First of all geographically, New Delhi was priority being the high urban first service centre, then we opened one in Mumbai, then in Bangalore. Recently during the year we opened one in Kolkata. And we see a lot of opportunites in Kolkata. You see a lot of opportunity when you are starting to see a vision. We see from ours results that the opening of the service centres has given our customers on the east coast the confidence that they can look for BITZER as a viable product in the market and they know, it can be serviced in case there is a failure. You can go back to the proper service centres and have a proper servicing with the original spare parts service is very important.

Green Point centrally provides rebuilt services back to original conditions it guarantees original parts. We only use original spare parts. And we provide quality. We test, built, and run, our all compressors, and we put them through test procedure which verifies their optimal performance. Original spare parts are also available and we sell them from the 'Green Point Service Centre'. Again when a customer comes to BITZER, he is assured that he gets original parts. And this also gives the customers a high confidence in our product. I think being a German Company of high reputation it is compulsion on us to supply this service mechanizes to give the customers a confidence. That is the result, so it can be a win for our customers and win for BITZER. It also provides a very good training system for our young guys that are doing well. We also provide training for system repair techniques, as it is part of Green Point. I think it provides very good service to the industry.

'You Can't See Our Products Anywhere. But You Can Feel Them Everywhere.' Refrigeration and AC technologies are key elements of our world. The BITZER Group has been making a contribution with innovative products and services for 80 years. Its products maintain the optimum temperatures on buses, trains and in buildings and ensure food stays fresh at all times. Perfection and precision shape the Group's operations. With efficiency, sustainability and specialist skills it promotes development in compressor technology as a market leader.

As a cold chain expert what eminent advice would you impart to the sea food and ice cream sector?

I believe very strongly that India in the next couple of years will do more export wise business and cold chain in India has very high part to play for food related export activity. On that basis we need to seek and be assured of HACCP conditions of any export related activity that uses cold chain. We need to ensure that the type of equipment applied is at the best possible level that it can be. We need to very well understand what the system load is, also quality of the refrigeration and enterprise is very important. Many people are getting interested in Indian export business and thus the whole system needs to be at the highest quality using genuine and uncompromising components. In this relation, German quality and experience can participate in the Indian nations Cold Chain infrastructure development. ■

Lessons learned in Heritage College Mechanical Room Refurbishment

When a 1920s heritage building needed to be refurbished, the challenge was to preserve its character whilst using modern building engineering services methods. PankajSoni, Country Manager for Victaulic in India, explains why the grooved pipe-joining system proved the ideal solution to replace welded HVAC pipework.

William Booth College in Denmark Hill, London, United Kingdom, was built for the Salvation Army to train its officers and opened in 1929. The main college building was designed by Sir Giles Gilbert Scott, architect of Battersea Power Station, Liverpool Cathedral and Bankside Power Station – now the Tate Modern art gallery on London's South Bank. In 1972 the building was Grade 2 listed for its particular architectural merit, and so any alteration requires the work to be sanctioned by English Heritage.

The college campus, which once housed the hunting lodge of the Prince of Denmark, extends over nearly eight acres of land. It comprises a four-storey teaching and administration block, seven accommodation blocks, a large church, dining room, plus sports, leisure and recreation facilities.

The buildings recently underwent major refurbishment which included the upgrade of HVAC systems. The project called for a refit of the central mechanical room which provides the district heating system to the entire site. The distribution piping, which conveys low temperature hot water and chilled water through tunnels to supply each of the buildings on the campus, also needed replacement.

Instead of replacing the existing welded pipe work with another welded system, the contractor selected a grooved pipe-joining system from Victaulic. The technology emerged more than a decade before William Booth College was opened. Since that time, it has been continuously developed by Victaulic to meet the present-day demands of the building engineering services sector and is used worldwide in a variety of projects.

More productivity

Today, as it was in the 1920s, cost is a major consideration in construction projects. More than eight decades on,

Pankaj Soni has worked in a variety of senior management roles for highly respected international engineering firms and has more than 20 years of professional industry experience. He is BE in Mechanical Engineering as well as an MBA. Currently he is Country Manager for India with Victaulic.

with costs in mind, the grooved pipe joining method was selected after the contractors conducted a review of their options. Peter Hanson, manager at mechanical contractor, Halsion Ltd, said: "We carried out a value engineering exercise at the start of this job and chose Victaulic because it was the most cost-effective & user-friendly option overall."

According to Hanson, the factors that contributed to the findings were the speed and ease of assembly that significantly decreased labour as well as the increase in safety. These factors contributed to increased productivity and the overall cost-effectiveness of the Victaulic grooved mechanical system.

Speed and safety

Because much of the work was conducted in tunnels, the inherent safety qualities of grooved mechanical systems played a significant role in increasing the overall productivity and speed of installation on the William Booth College project. Twentieth-century construction materials caused significant health and safety problems, as the tunnels were found to contain hazardous asbestos which had to be removed before work could begin.

Minimising health and safety risks was a key factor for the refurbishment programme and the risk of fire was a particular concern which contributed to the decision to use a flame-free joining method. Not only did the presence of dust increase the risk of fire, but the confined space in the tunnels made it even more desirable to avoid hotworks. Doing so removed the risk of sparks and hazardous fumes and eliminated the need for hotworks permits and fire watches – both of which can slow down the construction schedule.

Removal of asbestos and cleaning of tunnels had already caused a long delay to the start of the project. However, the speed of installing couplings and avoidance of time-consuming hotworks procedures made up for lost time and brought the programme back on schedule. Hanson commented, "Using Victaulic saved us time in several ways, including not having to get hotworks permits."

Both rigid and flexible couplings were used throughout the job on carbon steel pipe upto 200 mm in diameter. Pipe-joining was made even quicker and

easier by selecting Victaulic installation-ready couplings rather than standard grooved couplings. The installation-ready couplings were inserted directly onto the pipe ends - without the need to disassemble the bolts, nuts, gasket and housings - and tightened with standard hand tools.

The practical difficulties of welding were also overcome. "We avoided any positional welds that might have been necessary," Hanson explained. "Non-use of welding equipment was a major plus. Especially in the tunnels, where there's restricted access, it was better to use Victaulic."

Vibration reduction

Rubber arch bellows, commonly used to reduce vibration, were designed out at an early stage in the project and replaced with three flexible couplings sited on the suction and discharge side of the pumps in the mechanical room. Vibration attenuation is achieved as the coupling's construction enables the gasket to seal against the pipe, while the metal housing provides both space for the resilient elastomeric material to flex, and containment to prevent over stretching.

This creates a discontinuity similar to that of a rubber compensator. Additionally, the ductile iron of the external housing has its own vibration dampening qualities. Grooved check valves, butterfly valves, flow regulating valves and wye-type strainers were also used in the mechanical room.

Accommodation of thermal movement

Similarly, to accommodate angular deflection and thermal movement in the tunnels, flexible couplings and special mover expansion joints were installed.

Mover expansion joints (Style 150) were selected because they were not only simple to install but could easily be adjusted before installation to allow the required amount of axial end expansion or contraction. "We avoided using linear axial bellows but used Style 150s instead and placed them at intermediate points in the tunnels," said Hanson. "We put flexible couplings on turns of bends to take up a lot of movement as well."

Whilst allowing pipeline deflection and piping thermal movement, the coupling remains a self-restrained joint and its pressure-responsive design provides sealing even under deflection and pipe movement.

Despite the delayed start, which could have cost thousands of pounds, the project was successfully completed on schedule,saving the project timeline and with a minimum cost saving estimated at 15% compared with welding.

"It's always cheaper to use Victaulic than to weld on-site, and speed and cleanliness are added advantages," said Hanson. "Once again we pulled it off. Victaulic has done us well." ■

Ziehl-Abegg completes EC Motor Range

Motor and fan manufacturer Ziehl-Abegg is breaking into new market segments with a further motor size. This completion of its product range of energy-saving EC motors accompanies the introduction of new impellers. The combination of impeller and EC motor reduces noise and power consumption compared to the current market standard.

"Better household insulation increases the need for controlled ventilation", explains Product Manager Moritz Krämer the rising demand for fans for residential ventilation. This requires small fans that provide continuous reliable operation for many years. With the EC055 motor size, Ziehl-Abegg can now apply its expertise in the construction of efficient electric motors in this application area. The small EC fans are also used for heat pumps for water heating, in electronic cooling and in refrigeration.

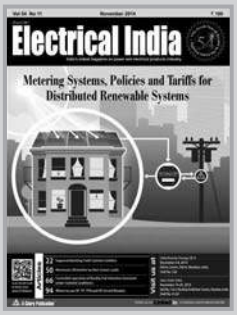
"Whereas in electronic cooling the focus is on power consumption, in

residential applications we also have to consider noise generation", adds Krämer. With this in mind, Ziehl-Abegg has designed a new centrifugal impeller for this application with a special backwardcurved blade design. "This centrifugal fan is the product of our decades of experience in developing optimum blade geometry", explains the engineer. The new centrifugal impellers can of course be used in other areas, too.

In the output range of 100 watts to 6 kW, there are only a few manufacturers of energy-saving motors in the world who can provide the full spectrum of products. With the so-called EC055 Ziehl-Abegg has brought a product to market that combines better performance and noise characteristics with standard installation dimensions. EC motors from Ziehl-Abegg are also known as "ECblue".

EC motors are direct current external rotor motors that are equipped with permanent magnets. When the motor turns, the electronic circuit determines the position of the rotor, which is then used to control the motor winding. This control is known as commutation, with the EC in EC motor standing for "electronically commutated".

The official product presentation will take place at the ISH in Frankfurt from the March 10-14 2015. This exhibition is the world's leading convention for bathrooms, building, energy, air-conditioning technology and renewable energies. ■



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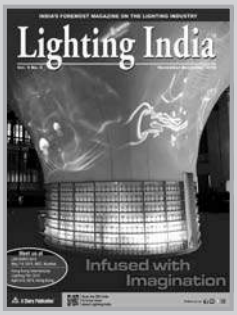

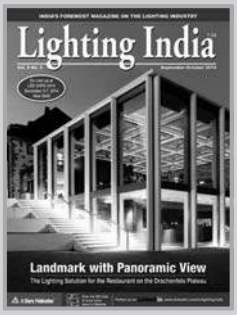

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Refrigeration Cycle

A Cooling Link for the Future

A Refrigeration and Air Conditioning cycle is a reverse heat engine cycle in which we have to work in the system and we are getting cooling effect as output which is used for different production process, preservating goods and other aspects.

The term refrigeration may be defined as the process of removing heat from a substance (i.e. process of cooling a substance). A refrigerator is a machine for producing cold. Refrigerators are used for making and storing ice, and for cooling of storage chambers in which perishable food is stored. Another large application of refrigeration is in the field of air conditioning. Here, refrigerator is used not only to lower the air temperature to the desired point but also to dehumidify the air (to remove excessive moisture present in the air) by cooling it to below dew point temperature. Refrigeration is also used in the manufacture and preservation of medicines and chemicals, in making and storing ice cream, & in water coolers.

Originally, refrigeration was obtained by the use of natural ice. This was not only inconvenient but very inadequate. With the development of mechanical refrigeration systems, the use of natural ice has become insignificant (unimportant).

Mechanism of Producing Cold

Refrigeration means reduction of temperature of body below the general level of temperature of the surroundings. It further implies the maintenance of the temperature of a body at a lower level of temperature than the surrounding. Consequently, it means the continued extraction (removal of the heat from a body whose temperature is already below the temperature of bodies in its neighborhood). For example, if a cold storage room is to be at a temperature of about -5^{O}C, we must go on continually pumping out heat which comes in the room through leakage from outside and also whatever heat is brought into the room with articles which are stored into it after the temperature has once been reduced to -5^{O}C. Again in the case of ice plant, the brine (salt solution) has to be maintained at a temperature somewhat lower than that at which water freezes (0^{O}C.). The heat which leaks in from all sources, has to be continually extracted from the brine at this comparatively low level of temperature. This heat which is to be extracted is raised to a higher level of temperature and is discharged there. It is discharged by giving it up to some substance which acts as a receiver of heat. Practically in all cases of refrigerators, the substance which absorbs or receives heat is water.

In a refrigerator heat is being virtually pumped from the lower level to the higher level and is rejected at that high level of temperature. This process, according to second law of thermodynamics, can only be performed by the aid of external

Dilip M Patel, MTech (Mech.),
Principal, Shree V & K Patel Institute of Engineering, Mehsana, Gujarat

work. Hence, supply of power from an external sources (say an electric motor) is required to drive a refrigerator. The total quantity of heat which is rejected to water is made up of tow parts. It consists of heat which has been extracted at the low level of temperature from the body that is being kept cold (refrigerating effect) and the heat which is equivalent to the mechanical work which has been spent in extracting it (work spent in driving the refrigerating machine).

Theoretically, a reversed heat engine will act as refrigerator when run in the reversed direction by means of external power. Such an engine will become a heat pump which will pump heat from a cold body and will deliver heat to a hot body. Thus, mechanical refrigerator operates on the reversed heat engine cycle. The physical idea about employing the reversed heat engine as a refrigerator can be conceived by comparing the arrangements of elements of the power plant cycle and refrigeration cycle.

The essential components of the units are-

- The power plant unit, and
- The refrigerating machine.

The direction of flow of the working fluid in the power plant is clockwise and the cycle follows the processes of evaporation, expansion, condensation and compression respectively in the components, boiler, turbine or engine, condenser, and feed pump. The nature of processes of the turbine and feed pump & the boiler and condenser are opposite.

If now direction of flow of working is reversed and made anti clockwise, and the order of operations also reversed such that, starting with evaporation, it is evaporation compression, condensation and expansion. It is seen that the components are required to be interchanged evaporator exchanging with condenser and compressor exchanging with expander. Thus, it can be said that by reversing the cycle completely in all respects, a cycle of refrigeration can be evolved which can truly be said as a reversed cycle. It may be noted that the working agent also requires to be changed to a refrigerating agent (refrigerant) to make the cycle practicable.

While discussing about refrigeration, we have to speak in terms of the cold body and hot body. The words cold and hot are to be relatively understood. A cold body is that substance from which heat is to be removed or its temperature is to be lowered. A hot body is that body to which we are rejecting the heat that is collected from the cold body, whereas atmospheric water used in the condenser for condensing and cooling purpose is the hot body and there is considerable difference in temperatures of these two bodies. In an extended sense, atmospheric air is the final hot body, because hot water leaving the condenser is cooled in atmosphere so that it can be re-circulated in the condenser. Hence, atmosphere is the big reservoir of heat to which all the heat extracted by refrigerating machine is rejected, but there is not any appreciable increase in its temperature because of its vastness.

Types of Refrigerators

There are two types of mechanical (mechanized) refrigerators, viz.

- Air Refrigerator in which the working agent employed is air,
- Vapour Refrigerators in which the working agent is vapour like ammonia, carbon dioxide, sulphur dioxide, freons etc.

The main difference between these two classes of refrigerators is the non-condensability of air & condensability and evaporativeness of the above named vapours within the working range of temperatures of the refrigerators. This means that for use in the refrigerator, the air cannot be subjected to changes of state (from liquid to vapour and vice-versa). In other works, air behaves as a perfect gas and heat changes are brought about by changes in temperatures only i.e. only sensible heat changes are taking place. Unlike this, in the case of vapours heat changes are in the latent heat form and fluid alternatively changes from liquid to vapour and back to liquid.

There are two distinct typer of vapour refrigerators. One is known as vapour compression machine and the other vapour absorption machine. The main difference between these two types refrigerators is in the manner in which external heat is added to the vapourised refrigerant. In the vapour compression system, the vapour from the cooling unit is removed by the suction of a compressor usually operated by an electric motor; the vapour is then compressed and during the process of compression external heat is added and temperature raised. In the vapour absorption system, a substance which has great affinity for the refrigerant is used to reduce refrigerant vapour

into liquid form to handle it conveniently. The combination then passes into another part of the system (heater), where the refrigerant vapour is separated and its temperature raised by the application of external heat. In this system, ammonia is the refrigerant used and water is the absorbing agent, since it (water) has great affinity for ammonia.

There are a few other types of refrigerators, such as steam-jet, thermo-electric, and vortex tube refrigerators. These are more or less of recent origin and may prove very useful in the field of refrigeration and air conditioning in the coming years.

Refrigerating Effect & Unit of Refrigerators

The amount of heat extracted in a given time is termed as the refrigerating effect.

As the earlier refrigeration machines replaced natural ice, the refrigerating effect of these machines was compared with the refrigeration produced by ice. The unit then decided upon was the refrigeration produced by the melting of a ton of ice, from and at 32^{O}F, in 24 hours. As the latent heat of fusion of ice is about 144 B.Th.U. per pound, a refrigerating machine which can effect refrigeration at the rate of 2,240 x 144 = 3,22,560 B.Th.U. in 24 hours was rated as one tone machine. Thus, a one ton of refrigeration is the rate of production of refrigerating effect. The unit is known as standard commercial ton of refrigeration. A ton of refrigeration on an hourly basis is 3,22,560/24 = 13,440 B.Th.U. and on a minute bases 224 B.Th.U. In America, one ton is take as 2,000 lb. and hence one ton of refrigeration works out to be 12,000 B.Th.U./ hour or 200 B. Th.U./minute. This is increasingly becoming a common practice. Basically, therefore, in MKS unit on tonnne of refrigeration is equivalent to 3,000 kcal/hr or 50 kcal/minute.

One tone of refrigeration is SI units is equivalent to 3.517 kJ/ sec. (≅ 210kJ/min.).

In Europe, the unit of refrigeration is the amount of heat required to raise the temperature of one kilogram of water by 1^{O}C in one second, i.e. 4.187 kJ per sec. One unit of refrigeration in SI units is equivalent to 4.187 kJ/sec. For example, if the rated capacity of the refrigerating machine is 25 units of refrigeration, the refrigerator is capable of extracting 104.68 kJ per second.

Coefficient of Performance

Thermal efficiency is used to express the effectiveness of a heat engine to convert heat energy into mechanical work. The effectiveness of a reversed heat engine (refrigerator) is expressed by a term known as coefficient of performance (C.O.P.). It is expressed by letter K. The coefficient of performance of the refrigerating machine is measured by the ratio,

$$K = \frac{\text{Desired refrigerating effect}}{\text{Mechanical work spent to produce the refrigeration effect both quantities being expressed in the same units of heat or work}}$$

C.O.P. of a refrigerator is usually greater than unity.

For refrigerating machine, the desired effect is the refrigerating effect, i.e. heat abstracted in a given time from the cold chamber. The most efficient refrigerator is that machine which will abstract the greatest amount of heat for a given quantity of work spent.

Let N = refrigerating effect,

= heat abstracted from cold body in given time, and

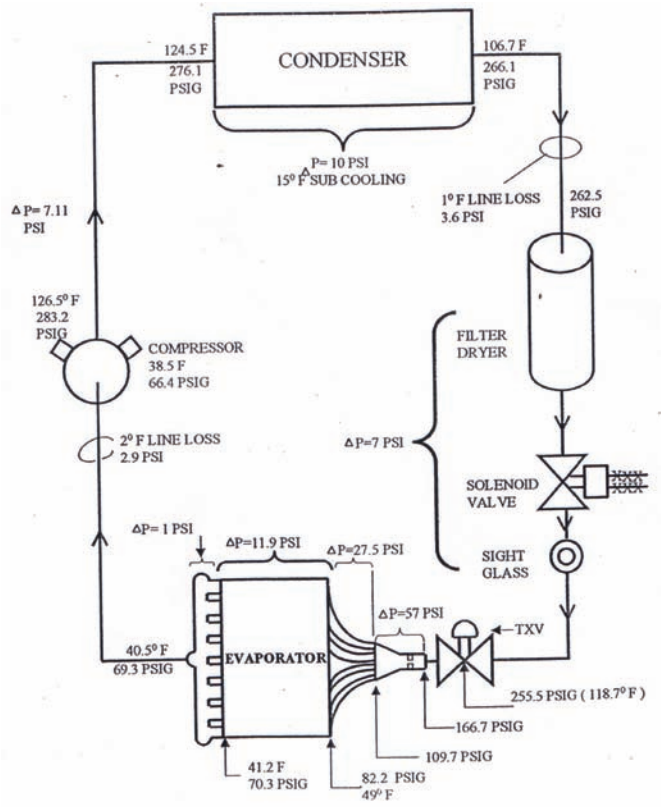
W = work spent in driving the machine in same given time.

$$\text{Then, coefficient of performance, } K = \frac{\text{Refrigerating Effect}}{\text{Work required}} = \frac{\text{Refrigerating Effect}}{\text{Heat equivalent of power required}} = \frac{N}{W}$$

If the values of N and W are measured during an actual test on the refrigerating plant, C.O.P. obtained from these values will be the actual coefficient of performance. The theoretical values of N and W may be obtained from ideal cycle of the refrigerator. The corresponding value of C.O.P. is known as the theoretical coefficient of performance. The ratio of actual and theoretical coefficient of performance is known as relative coefficient of performance. The most efficient refrigerator has the highest value of its coefficient of performance.

Air Refrigeration System

Refrigerators using air as the working medium (working substance) operate on either reversed Carnot cycle , or reversed Joule cycle, more commonly known as Bell-Coleman cycle. Air as a refrigerant has two outstanding advantages: it is available free of cost, and leakage will not cause any trouble. Thermodynamically, air is a poor refrigerant & was abandoned



enhance comfort and energy efficiency

Honeywell's new Kombi 8 Series pressure independent integrated balancing control valves leverage the most innovative design and cutting edge technology, to provide comfort and convenience to customers.

These valves combine three functions - linear temperature control, pressure independence and electrical modulation in one valve. This ensures accurate linear temperature control, easy to operate, elimination of balancing hassles in hydronic systems, enables HVAC systems attain the highest standards of energy efficiency and cost savings. Ideal for both new installations as well as retrofits.

Their robust construction, easy-to-install design and long life make them truly next generation valves.

Honeywell

Honeywell Environmental and Combustion Controls, Honeywell Automation India Limited, 56 & 57, Hadapsar Industrial Estate, Pune 411013. (India)
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(give up) with the development of vapour refrigerants with superior thermodynamic properties. However, air refrigeration is now increasingly used for cooling of aircrafts and cargo ships.

Principle of Operation

The normal Carnot cycle uses heat energy and delivers mechanical work as energy output whereas in Refrigeration and Air Conditioning it is the reverse Carnot cycle operation. This means work is supplied as energy input and heat is transferred from lower energy level to higher energy level.

The normal strategy of mechanical refrigeration is first to get heat into refrigerant. Then elevate its energy level and temperature level and pump it to a place where heat can be removed from it. The refrigerant makes this heat transfer possible.

Most of heat transfer takes place through latent heat by changing phase from liquid to vapour in evaporator and from gas to liquid in condenser.

In open cycle refrigeration the substance doing cooling is open to atmosphere. The common examples are old-fashioned icebox, an earthen pot for water, liquid nitrogen or solid carbon dioxide commonly known as dry ice. Even refrigerant if allowed to escape to atmosphere through a cooling coil and pressure-reducing valve, it would give cooling. However, it is extremely expensive to allow the gas to go to waste, it is also illegal to vent the gas to atmosphere in most of the countries. We use close cycle refrigeration, as we want to make use of gas again and again.

Even in closed cycle refrigeration if we do not use compressor and metering device, a closed cycle refrigeration system will not achieve the objective, as heat will then flow in a reverse direction till the temperatures are equalized. The heat will flow downhill from ambient to inside the premises if the ambient temperature is higher than inside.

As water cannot move from lower level to higher level without pump, and since we have to reject heat uphill, we require compressor and mechanical energy to raise the level of refrigerant.

Normal evaporating temperatures for Air Conditioning application are between 40 to 45^{O}F (4.4^{O}C–7^{O}Cc), while the room is being maintained at 75^{O}F (23.9^{O}C) and the supply air to the room is around 50 to 55^{O}F (10^{O}C–12.8^{O}C)

Similarly for 95^{O}F (35^{O}C) ambient temperature, the air-cooled condenser operates at around 120^{O}F (48.9^{O}C) sat. Temperature 170^{O}F (76.7^{O}C) actual gas temp.) This corresponds to 263 psig. (18.8 bar)

Normally the design is based on 15 to 25^{O}F(8.8^{O}C – 13.8^{O}C) rise /fall in temperature across condenser /evaporator.

The metering device and compressor separate system components in high side and low side of the system.

The high side comprises of part of compressor, discharge line from compressor to condenser, condenser, liquid line, and inlet of expansion valve.

The low side comprises comprises outlet of meeting device, evaporator, suction line and compressor inlet.

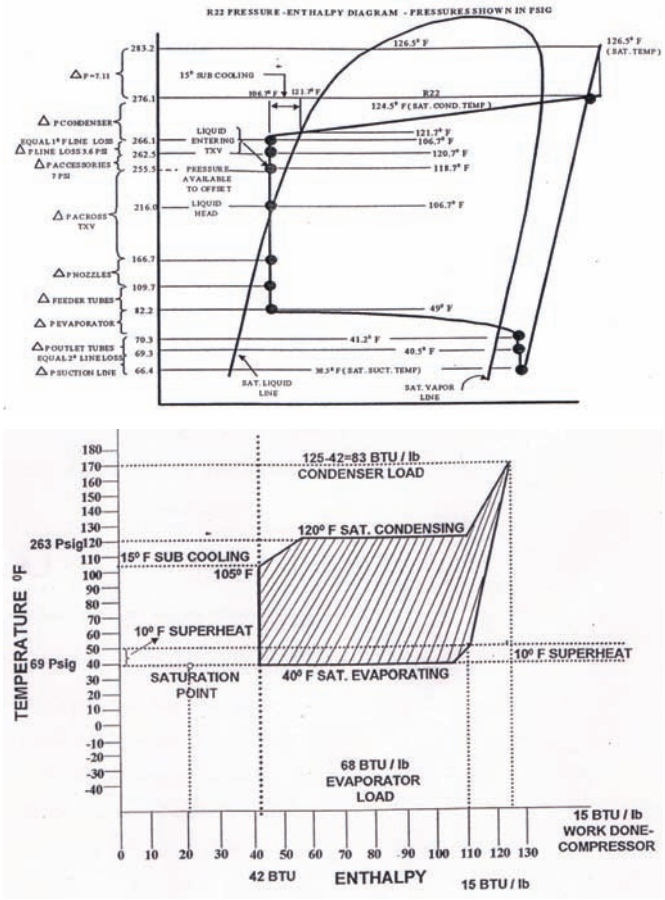
The function of 4 major components is as follows -

- An evaporator to absorb heat into the system.
- A condenser to reject heat from system.
- A compressor to establish temperatures and pressures necessary to force heat to flow upwards.
- A liquid metering device to regulate the flow of refrigerant and in the process to establish two pressures levels.

An evaporator when used to cool liquid, which could be water/brine, is called chiller. Normally for Air Conditioning duty liquid chillers are used above 100 Tons capacity invariably. Similarly condensers could be air-cooled or water-cooled.

The compressor is a mechanical device that boosts pressure from low side to high side of refrigeration system. Heat of compression added is about 22 to 30% to the heat absorbed in evaporator.

The condenser therefore has to reject this additional heat. Hence condensers are normally 15 to 20% bigger in surface area than coolers for identical design and temperature differences.



Component function-Summary

- Evaporator absorbs heat from conditioned space into system. This causes refrigerant to get converted from low temperature, low pressure, saturated liquid/vapour mixture into low temp, low pressure superheated gas.
- As gas enters compressor it is reduced in volume, then compressed into high temperature, high pressure, and superheated gas.
- As gas passes through condenser, heat is rejected so that it changes into high temperature, high pressure, and sub-cooled liquid.

- The metering device takes this liquid and regulates flow to evaporator and puts it through desired pressure drop. In this process, refrigerant changes into low temperature, low pressure, and saturated liquid/vapour mixture. The cycle repeats.

  The pressure enthalpy diagram helps us to
- Trouble shoot mechanical refrigeration system.
- See function of each part & how they work together to change pressure and move heat.
- Predict pressures and temperatures to be expected at various places in the system.

Gives an important tool for learning other principles about refrigeration systems.

$$\text{Ton} = \frac{2000 \times 144}{24} = 12000\text{BTU/hr}$$

$$\text{COP} = \text{Co} - \text{efficient of Performance}$$

$$= \frac{\text{Capacity in kW}}{\text{Power consumption in kW}} = \frac{\text{Ton} \times 3.5}{\text{kW}}$$

$$\text{EFR} = \frac{\text{BTU/hr}}{\text{Watt}} = \frac{\text{Ton} \times 12000}{\text{kW} \times 1000}$$

$$= \frac{\text{Heat removed over a period}}{\text{Total energy in put in Watts during same period}}$$

IPLV = Integrated Part Load Value
ODP = Ozone Depleting Potential
GWP = Global Warming Potential
TEWI = Total Equivalent Warming Impact

Ref.: Ahmedabad Comfex-2005 Seminar. ■

Aim for 200 percent expansion in production & marketing

Sreevalsan Menon, *CEO, CoolTech Containers Pvt Ltd, in an exclusive interview with* ***Cooling India*** *says, our containers provide better mileage for vehicles and reefers due to lower weight of the frame and its design advantages.*

According to you what is the status of cold chain industry in India?

As per a recent report by Assocham, the Indian cold chain industry is growing at a phenomenal rate of 28%, taking the total value of industry in India to touch USD 13 billion by 2017. I believe rising investments, rationalization or modernization of existing facilities and creating new ventures in the PPP space are all leading to tremendous opportunities for players like us. Though I agree that the present status of the suppliers is not very heartwarming as they are all in the state of evolving and unorganized, I see tremendous scope for growth for those who offer innovative technology, durability, better value for money and complete understanding of Indian road conditions and entrepreneur expectations.

From ASSOCHAM, I understand that the Indian cold chain market is highly fragmented with more than 3,500 companies and where the role of organized players like us is limited to just 8–10% of the cold chain industry market which also gives us a chance to grow since Indian companies are far more aware of the quality required for retail or other ambience driven transport of goods. Look at the facts; 11% of world's total vegetables production is accounted for by India, 127 mn tonnes of milk get produced though India has a storage capacity for just 70,000-80,000 tonnes and 20%-30% of fish production is annually wasted in India. There are many more interesting facts which all point to the fact that we have a incredible outlook ahead.

Could you describe features of CoolTech Containers and how they stand distinguished than other transport containers?

We are proud to say that Cooltech products have clear and defined advantages unlike mild steel-heavy (not rust proof) and GRP-Light weight containers (not very suitable for Indian road conditions).

We have launched new generation GRP boxes which have the following features:

- No wooden planks, plywood and glue (all these materials are used in international container construction but found to be highly ineffective for Indian roads/climate)
- Fully welded construction (first time in the world, suitable for Indian roads/climate conditions)
- Light weight
- No scope to develop cavity (inside the container)
- All exposed components are stainless steel 304 only and
- Highly hygienic.

What latest technologies your refrigerated vehicles have for transportation of perishable goods? Also what is the major distance the refrigerated vehicle have covered so far?

All discussed above. Our vehicles have already covered distances between Delhi-Mumbai, Coimbatore-Delhi and Kolkata-Mumbai.

Could you tell us what the highest capacity container available with you is and what refrigeration temperature range could be achieved?

The highest capacity container available is 32 centimetres with refrigeration temperature range upto 25 degree.

Why Cool Tech should be called as provider for customizing cold chain solution?

Cooltech containers are light weight compared to the existing ones. Our containers also have better temperature holding capacity due to the absence of cavity and our innovative PUF insulation. We have effectively sealed heat loss and endurance issues, studying issues that have affected around 10,000 containers, at present in operation across India. Some of the improvement.

The containers we provide are 100% sealed and puf slabs of computerised quality are used for insulation.

On what basis you say that Cool Tech's refrigerated vehicles gives the highest ROI and 20% saving in all fronts? Could you highlight some of the major features?

Our primary assertion is that our containers provide better mileage for vehicles and reefers due to lower weight of the frame and its design advantages. It also ensures cold retention for longer hours besides faster turnaround time. We attribute these to the materials used in and outside, as well as design advantages as explained earlier. The easier maintenance and longer life lead to greater savings in terms of lesser fuel and tyre consumption for the carrier and lesser cooling requirement in terms of air conditioning. Our experience shows that our containers, due to their lower overall weight, can accommodate more volume thus more savings for the transporter, which we effectively calculate as higher RoI and an investment that can be recovered in nearly two years.

Tell something about reefer transport in India. What is the maximum cooling duration for refrigerated vehicles? Explain how design proficiency can give higher AC life?

I don't think I can explain all these aspects in few words yet I would like to point that our innovation in the thermal insulation and the customized air leakage properties of our containers are definitely a cut above the rest, comparable with internationally accepted values. Overall, our Insulated Body will have double leaf-insulated doors, fitted with inner and outer seals and an easy locking mechanism. This, along with the all-welded outer shell and special design for return air evaporation ensure a better performance of the refrigerating machine.

What transformations are taking place in cold chain industry with respect to technology nationally and globally?

The cold chain segment overall has gained greater national attention with various state governments offering several incentives and companies coming forward to invest more resources in these products. The scenario is ideal for players like us as there is a huge market potential for cold chain logistic solution providers. Cooltech with its fully welded GRP containers – a first for the country itself – is here to exploit the opportunities presented by this industry.

What expansion plans do you have and what do you envision in the next two years?

We envision and aim for 200% overall expansion in both production and marketing in the next two years. ■

CoolTech Containers - India's most advanced and environment friendly containers also have the best return on investment in the industry. Due to the sheer benefits of our eco-friendly design, sophisticated materials and customised pack, our refrigerated vehicles give the highest RoI, and 20% savings on all fronts. After sales services team is specified to client in advance. Four assembly units are ideally placed to service customers. Company's products are now visible in Mumbai, Bangalore & Chennai and soon to be seen in Mangalore, Surat & Delhi.

Standard Chartered's Malaysia HQ equipped with RDM total control and monitoring

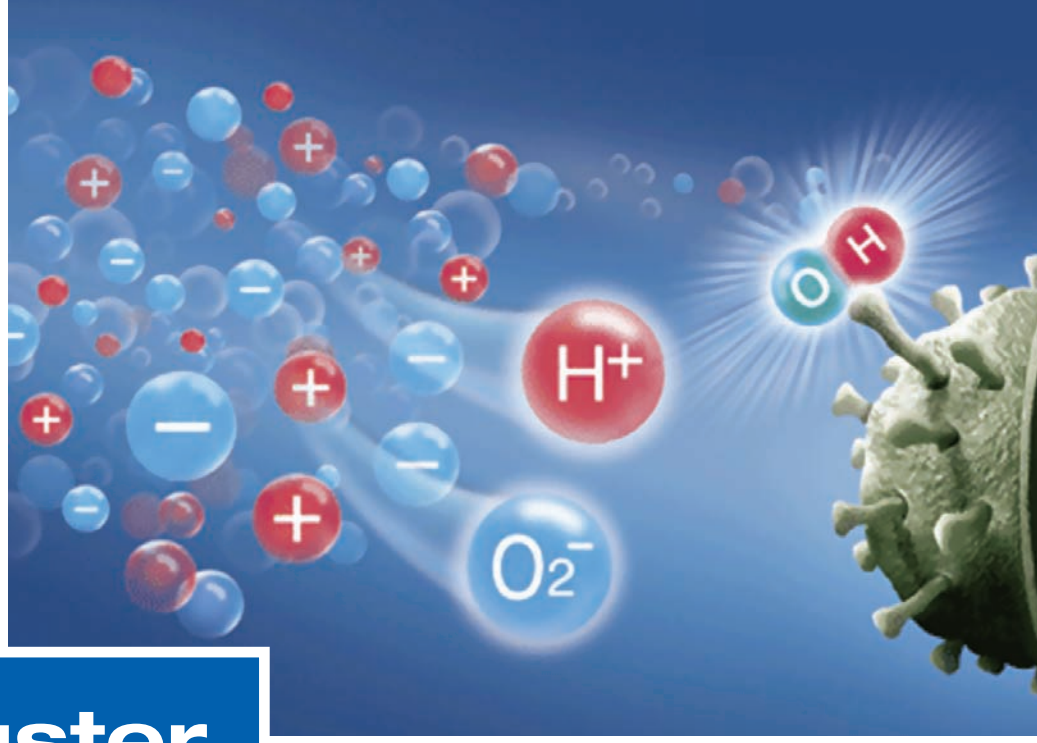
An advanced Resource Data Management building management system (BMS) is providing total control and monitoring for the new flagship headquarters of Standard Chartered bank in Malaysia. The building, located in the prestigious Technology Park Malaysia complex in Kuala Lumpur, consists of numerous retail outlets, restaurants, parking and office accommodation.

Due to the nature of the main tenant's business in banking and finance, the building accommodates a substantial IT infrastructure. Given this, and the high quality, low carbon environment specified, an all-encompassing building management and monitoring solution was necessary.

The RDM system chosen provides complete control of the building's VRV and split air conditioning systems, smoke exhaust fans and booster pumps, lighting, lifts, generators, and fire and security systems. It also looks after air handling units and pressurisation fans. Integrating these systems enables the RDM solution to exercise fine control over critical indoor climate parameters such as temperature and humidity, to maintain optimum environmental conditions for occupants and IT equipment.

It uses a sophisticated "Comfort Index" that takes account of both actual and predicted weather conditions, to anticipate changes and significantly reduce energy consumption, while maintaining the desired environmental conditions.

A key requirement is to record energy use throughout the building, so that it can be managed proactively to minimise running costs. The RDM system monitors the performance of every item of energy-using plant and equipment, and uses specially developed algorithms to predict potential future failure. Andrew Chandler, founder and managing director of RDM, remarks, that the approach to BMS is to offer a highly customisable system, that can be tailored exactly to a client's needs. Unlike other systems, which force end users to adopt a rigid approach to configuration and operation, RDM offers total flexibility and transparency. ■



Plasmacluster Ion Technology
The Future of Air Purification

Is our Indoor environment cleaner than the city outdoor? Several studies reveal that, Indoor Air is many times polluted than our city outdoor. Recently, Global Burden of Disease (GBD) count, a global initiative involving the WHO has declared indoor air pollution, as the highest killing source in Asia specially India.

It is due to land & sea breeze that exchanges the outdoor air twice a day. This does not happen indoors due to inadequate cross ventilation, especially in winters and monsoon when the doors and windows are mostly shut. Buildings in our city have come closer making the situation worse. These make our Indoor air stale and stuffy thus contributing heavily to the growth of infection causing germs leading to several life threatening diseases. The tuberculosis bacteria and several fungal growths are very common in Indoors with carpets, wooden floor, furnishings. In case of a weak immunity system, continuous exposure to these harmful substances may lead to Tuberculosis or any other Acute Respiratory Infections. The type of material we use in lifestyle of our homes including the paints, colors, chemicals and the improper ventilation systems give rise to dust mites, allergies and asthma which directly attack our immune system. Even the use of air fresheners, perfumes and smoke generated while cooking add to the amount of VOC present in the air. The VOC's are a major source of causing Sick Building Syndrome resulting in several respiratory triggers among many. The rate at which these diseases have increased over the last few years is an eye opener. Moreover to top it all our children are most affected.

We make various efforts like dusting and mopping to keep our Indoor clean, but unfortunately it is "Clean from far, far from clean". Our indoor air is neither clean, nor it is fresh and on the other hand the city outdoor is fresh, but is highly polluted.

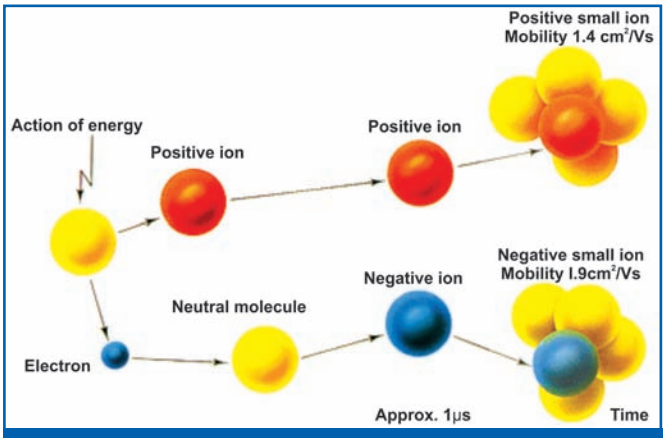
We typically spend 90% of time in Indoor like our home, offices, public transport etc that are stale & stuffy making us breathe polluted, stale and unsafe air. We eat thrice, drink water about 15 to 20 times, but an adult breathe 20,000 times a day. Air is the most important substance going into our body from outside which is by the way completely ignored by us. We invest on all types of gadgets that enhance our lifestyle and status in the society, but have bargained the threats due to poor air into our life.

Shuvendu Mazumdar, is Product Head at SHARP – Plasmacluster Air Purifier Business in India.

Several health authorities have recognized that certain types of air purifiers are beneficial in reducing the amount of harmful substances in a room. The American lung association recommends using an Air Purifier for the bedrooms of asthma sufferers. The United States Environment Protection Agency (EPA) research has shown that good Air Purifiers, even those of the smaller, portable variety, are up to 90% effective in reducing these smaller particles, such as those caused by pet dander and dust mites.

Asthma Society of India and British Allergy Foundation also test air purifiers and provide them seal of approval on their effectiveness in removing several Volatile organic Compounds (VOC), pet hairs and other allergy causing matters.

Selecting the right Air Purifier also is important for a home or office. Here are some tips for us to decide:



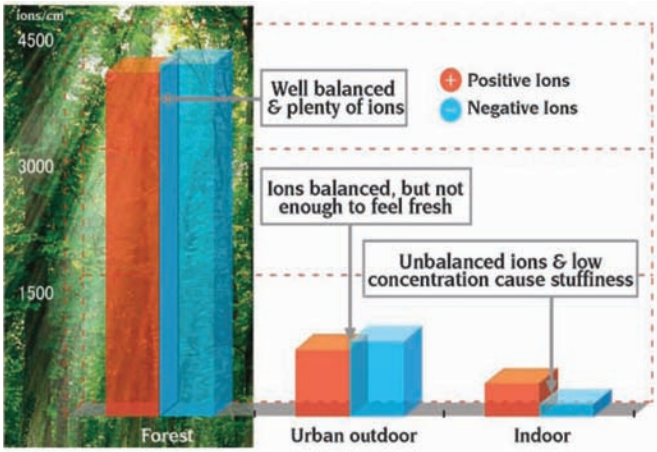
Schematic illustrating the production of atmospheric small icons from neutral molecules

When we look at some suspended particles in the air we assume that it is polluted, however the truth is that by simply looking at the air, we cannot determine whether it is clean, fresh or polluted. When we spend a holiday in forest, hills or resorts we feel very fresh and rejuvenated. This is because of the high concentration of Positive and Negative Charged Ions (typically about 4000 ions per cm^3) in such natural environments.

Hence, it is actually the level of the Positive and Negative Ions that determine the freshness of the room.

If we are able to regenerate the Positive and Negative Ions in the same level at our indoor through Plasmacluster mechanism (Plasmacluster Ion Technology mimics nature), we can generate Fresh Air.

The Positive and Negative Ions (Only with Plasmacluster Ion Technology) also create a substance called Nature's Detergent (Hydroxyl) which is highly oxidizing that crack the DNA and takes off the protein layer thus rendering it dead and ineffective. This way the micro-



organisms are raptured and rendered dead. The Positive & Negative Ions generated with Plasmacluster Technology generate fresh air, kill infection causing germs and triggers for Asthma, Allergy etc, from surface and air, neutralize odour and improve texture & elasticity of our skin. The Plasmacluster Ion Technology can definitely be called as the future for Air Purification with verifications from 22 Research Organization and more than 4 crore satisfied users.

The EPA also emphasizes that Sharp Air Purifiers are not meant to be a substitute for the proper ventilation system of your home's air. However, in conjunction with them, Sharp Air Purifiers help control the levels of harmful micro-organisms including those associated with allergens.

What is Indoor Air Pollution?

The homes that we build now are mostly sealed and allow very little cross ventilation with less or no sunlight in the rooms. The kitchen smoke circulate within the rooms is another cause of worry. The paint fumes and furniture emit harmful VOC's. Static Electricity generated in dry environment is another reason for carpets, furnishings and soft toys becoming a breeding ground for dust mite, pollen and other harmful gases. In the coastal areas mould and fungi grows due to high moisture

that create havoc to our lungs. Living in urban environment also results in several harmful industrial gases entering our home and getting trapped inside. As a result of all these and many more the Positive and Negative charged Ions which are a natural ingredient of fresh air (Ions in the Atmosphere – as attached) gets depleted and Indoor air becomes very stale, stuffy and heavy to breathe. It is easy to calculate that the time spend by us in an Indoor environment (home, office etc) is gradually increasing and hence our immune system is facing challenges due to continuous bombarding of this stale and polluted air. Our body is psychologically programmed to accept fresh air. In the absence of it, our Immune System spends most of the time to fight against the diseases that we breathe and thus become tired and lose stamina.

Statistics reveal that more than 93% of leave days in India is due to sickness from airborne diseases (eg – Cold, cough, sore throat, fever, sinusitis, allergy, asthma, tuberculosis and many more). India has seen the highest number of H1N1 deaths. Over 25% of city children suffer from Asthma!!

How is Fresh Air important for us!

Just imagine a typical 24 hours in your day; how many hours in a day are you getting Fresh and Clean Air? If you think about it, it will be a surprising ZERO.

Although we Indians are concerned about the pollutants entering our body through the respiratory tract, but a simple question always repels us back? What if we are used to fresh air like water? A simple answer is that we must understand the working of cardiovascular system (mainly air) is completely different from our Digestive system (Food and water)

We eagerly and happily spend money on eating out, movies, a yearly holiday, expensive mobile phones and clothes etc, but we forget that AIR is the most important substance going into our body from outside. Imagine a Petrol Engine running on a mixture of Petrol and Kerosene! If we breathe AIR and Pollutants together, our Immune System is challenged, gets tired and the performance gets affected.

We easily take shelter of Doctors who prescribe several expensive and harmful antibiotics to fight the common flu etc, if we rethink and use PREVENTION than CURE for airborne diseases, we might look forward to be a healthy nation.

Breathing fresh air for at least 8 to 10 hours a day will nourish our Cardiovascular system and rest the Immune System thus giving the stamina and energy to fight diseases while in challenging environments.

What is the best method to get Fresh Air in our Indoor?

When we visit of our historical monuments, we realize the importance of fresh air!! All the historical monuments build in India or abroad have provisions for Fresh Air and sunlight!! But the homes that we build today, in-spite of our perceived best architectural designs, we fail to comply with this basic need.

Cross Ventilation is the best way to get Fresh Air in our Home. But in our urban living condition once we open the window to get fresh air we also welcome a lot of pollutants. Again, when we look at some suspended particles in the air we assume that it is polluted, however the truth is that by simply looking at the air, we cannot determine whether it is clean, fresh or polluted. When we spend a holiday in forest, hills or resorts we feel very fresh and rejuvenated. This is because of the high concentration of Positive and Negative Charged Ions (typically about 4000 ions per cm^3) in such natural environments. Hence it is actually the level of the Positive & Negative Ions that determine the freshness of the room. The Positive and Negative Ions (Only with Plasmacluster Ion Technology) also create a substance called Nature's Detergent (Hydroxyl) which is highly oxidizing that crack the DNA and takes off the protein layer thus rendering it 'Dead and Ineffective'. This way the germs and triggers for Asthma, Allergy, Viral, Cold, and Tuberculosis etc can be killed and all odours neutralized from 'Air & Surface'. ■

BLAST FREEZING MACHINE USING BITZER SCREW COMPRESSOR

FAST BLAST FREEZING TIMES TRUST BITZER COMPRESSOR

BITZER high technology German refrigeration compressors & units are ideally suited to Blast, Trolley & Tunnel freezers for the Indian Meat & Chicken Industry.

The heart of any refrigeration system is the compressor, BITZER screw compressors offer unrivalled performance & capacity in single refrigeration condensing packages complete with electrical, control and operational components for trouble free service.

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Supreme introduces INSUflex, a High Vapour Resistant Insulator for Air-Conditioning Applications

Supreme Industries Ltd., founded in 1942, pioneered many path-breaking products in the country & became trendsetters in plastics industry by introducing many advanced solutions for various applications and industries. Supreme's Insulation Division offers solutions in the areas of:

- Ducting & Underdeck insulation
- Pipe & Floor insulation
- Insulation joint sealing tapes
- Sound insulation
- Overdeck insulation
- Wall insulation.

The main goal of a good insulation material should be that of preventing water vapour from spreading through insulation as water is an optimal heat conductor. INSUflex, by Supreme Industries, is a CFC-free, black flexible elastomeric closed-cell Nitrile Rubber thermal insulation that provides a highly efficient method of insulation and effectively controls condensation against both heat loss and heat gain. The material is particularly suitable for insulating pipe works for condensation control. It can be used on chilled water pipe lines, refrigerated pipe-works, hot & cold water services and on sheets or rolls in air-conditioning ductworks.

INSUflex, has a very high diffusion resistance factor to water vapour transmission ≥7000, a low thermal conductivity and an excellent fire safe performance. It is suitable for a temperature ranging from –55^{O}C to +105^{O}C. The product does not depend on any additional outer thick skin or covering but is in built with the insulation and extends through the full thickness.

INSUflex range is resistant to corrosion, fungal and mildew growth and is therefore suitable for clean room applications. Insulation material with a low 'K' value equates to a high energy saving potential and thermal performance. Thermal conductivity is the main data used to technically calculate insulation thickness required to prevent condensation.

INSUflex advantage

- Good flexibility at low temperature
- Clean, dust-free, fast and easy installation
- Low thermal conductivity
- High water vapor resistance factor ≥7000
- Protects pipes against corrosion by environment elements
- Low toxicity index offers minimal toxic fire hazard for safety assurance and rescue operations
- Good fire performance, for buildings with high occupancy, Class 1 product
- Unique closed-cell structure, provides an ideal vapor barrier resistance

INSUflex is available in combinations of various wall thicknesses and diameters to suit G.I., copper and PVC pipes.

The product is applied to the surface using an adhesive compound. A protective layer of glass cloth, in two layers with an adhesive compound is then applied before providing a weather barrier, such as aluminium / G.I. cladding for outdoor application.

Other INSU Range products

'INSUshield' is a non-fibrous, fire retardant ('Class O' in Fire Propagation and 'Class 1' in Surface Spread of Flame), closed cell, tri dimensional chemically crosslinked polyethylene XLPE foam. An ideal environment friendly insulation material, with a perfect solution for all your insulation needs for ducts, roofs, pipes, vessels, etc. The divergent advantages of 'INSUshield' are ease of installation, low thermal conductivity and good moisture & vapour resistance preventing microbial growth and optimum condensation protection.

'INSUreflector' is a radiant heat reflective insulation material made of polyethylene air bubble film (ABF) laminated with aluminum foil on one or both sides. It is a low e-reflective insulation material with a low mass to air ratio, which effectively blocks the radiant heat transfer. The bright surface of the aluminium foil, which encases the FR polyethylene air bubble material, reflects 96-99% infrared radiation received by the surface of the heated slated roof.

Amongst others, there are 4 primary reasons why Supreme's Thermal Insulation Division is a choice of discerning customers seeking superior insulation solutions.

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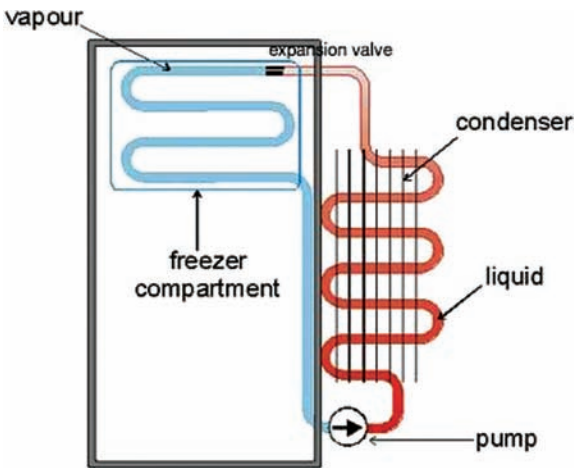
Technologies for Waste Heat Recovery from Refrigeration Systems

As refrigeration has become a way of life in modern lifestyle so has been the need for waste heat recovery. Refrigeration from small scale household units to industrial scale units has a large scope of waste heat and scientists & engineers to meet the demand of sustainable development with energy conservation and less environmental pollution are developing new technologies to recover & utilize waste heat from refrigeration systems (small or large).

This article briefly highlights the need of waste heat recovery, potential of waste heat recovery in refrigeration units and introducing the latest technological developments towards waste heat recovery & utilization from refrigeration systems. The process of refrigeration has traditionally involved a substantial use of electric energy. Energy recovery has become incredibly important in all aspects of the commercial refrigeration industry in recent years. Supermarkets in particular comprise a significant proportion of energy use as well as heat waste disposal. Supermarkets, ice rinks, and warehouse food storage facilities have each drawn the attention of concerned consumers and environmental protection agencies. Many companies have addressed these concerns with the state of art development of their energy recovery systems for refrigeration.

Waste heat recovery

Energy conservation is a major focus point towards sustainable development and waste heat recovery is a very useful energy saving technique where the heat that is removed by the refrigeration systems or other processes can be utilized for various applications as opposed to this heat just being wasted, as is normally the case. Considerable energy savings can be achieved by re-using heat from the refrigeration plant or any other process present on site. Depending on the specific temperature requirements of other cooling and heating loads throughout the facility, recaptured heat can be re-used directly, boosted through a heat pump to a higher temperature, used in an



Dr S S Verma, working as Associate Professor in the Sant Longowal Institute of Engineering and Technology is MSc and a PhD from IIT Delhi. He did postdoctoral studies in Japan at Toyohashi University of Technology. He has published about 40 research papers in journals and about 400 science and technology related articles. He has been nominated for various awards by International Biographical Centre (UK).

absorption chiller to satisfy another cooling requirement or stored for later use. Through extensive expertise with refrigeration and other thermal systems, one can identify and assess the viability of a waste heat recovery system, design a practical and sustainable solution and manage the project through the implementation. Energy recovery is accomplished when traditionally discarded heat is rerouted for other uses in the production process. Energy recovery ventilation systems are widely popular among owners and operators of existing refrigeration equipment. Virtually any existing equipment can be modified or adapted to accommodate green standards of energy recovery. Energy recovery ventilation systems are extremely adaptable, and can be customized to suit nearly any existing equipment. These energy recovery systems are extremely useful and efficient for reducing the hazardous impacts of heat waste upon the environment. They also preserve the use of expelled energy and conserve by efficiently distributing derived resources with those that are implemented.

Although compressor-driven refrigeration is far more dominant in today's market, absorption chillers are slowly gaining more traction in a variety of applications. Using heat instead of electricity to drive the cooling system, the absorption refrigeration cycle provides a way to make use of waste heat when another cooling load is present. Having much less moving parts then conventional compressor-driven chillers, an absorption chiller can be seen as a static system that runs noise free and has low maintenance and service costs. Absorption chillers operate on two fluids, an absorbent and a refrigerant. Commercially available absorption chillers either run on the LiBr-Water or Water-Ammonia working fluid pair. Each project needs to be specifically assessed to determine project feasibility. Further, introducing the use of compound refrigeration systems with integrated heat pump function has further improved its energy efficiency. The compound refrigeration systems use the entire waste heat from a commercial refrigeration installation to heat the store in winter. Up to an outside temperature of zero degrees Celsius no additional room heating is required. The compound refrigeration system is fitted with two additional compressors to ensure that this principle even functions on cold winter days when outside temperatures plunge below zero. These compressors work in winter as heat pumps and in summer function as refrigeration systems.

Technological developments

The heat generated from a compressor's activity during refrigeration process has long been emitted into the atmosphere. A simple change in technology, however, can make these compressors more powerful and efficient, and therefore able to divert that once-wasted heat for additional uses. Refrigeration technology really had not changed much in 150 years, with the result that no process had existed to convert heat released by compressors into other heating or cooling uses. Most refrigeration compressors use a traditional male-female rotor alignment to compress gas. While this ensures a smooth operation and seamless processing of gases, there is a limit to how much pressure such a system can handle. Refrigerants such as ammonia are one option for companies to consider, both for its efficiency and the fact it does not contribute to ozone depletion or greenhouse gas emissions. But, for demanding industrial heating and cooling applications, plant managers had shunned ammonia because no compression pumps could handle this refrigerant at high pressure levels. The solution was a single screw compressor system. The mechanism looks simple: it is simply one main rotor that inter meshes with two gate rotors on both sides. The compressor's design actually allowed gases to be processed at very high pressures–and higher differential pressure ranges–while offering low life-cycle costs. Because of the single screw's compressor-balanced design, a factory also benefits from lower maintenance and operational costs because of their decreased strain on the compressor's bearings.

Energy recovery is one of the most prominent concerns for consumers and corporations, particularly in the commercial refrigeration industry. Energy recovery equipment has been made available by several companies in recent decades. Industry leaders have accomplished with single units what companies earlier have tried to revolutionize in years past. Energy recovery is accomplished in two major ways. Heat is absorbed during the process of cooling, and released at high

pressures through stainless steel pipes. This effectually reduces the impacts of harmful waste, and utilized the absorbed heat as a form of energy. Energy derived from the absorption process can be derived to other components as heat recovery. Energy recovery is accomplished, and energy recovery units are efficient in reducing cost and harmful output. This allows the entire facility to function on far less energy than traditional with systems. Energy efficiency is a key issue for every facility where new refrigeration equipment is being installed. Recent developments in heat recovery systems offer the potential for reducing energy bills. Energy recovery units in refrigeration require the knowledge of experts from the initial model to the implementation process. Maintenance, modification and adaption procedures for virtually any part of the energy recovery process are offered by the innovative engineers. The model with the latest technology and system management has brought a new frontier to the refrigeration industry, particularly for commercial endeavours. Supermarkets, ice rinks, and storage warehouses are now extended accessibility to the benefits of energy recovery units for commercial refrigeration. Energy recovery ventilation systems bring a new aspect of environmentally friendly processing to the refrigeration industry.

GEA Refrigeration Netherlands N.V. won the Dutch Refrigeration Prize last month for technology that combines a refrigerating plant and a heat pump. The Energy Enhancer, the name given by GEA to this refrigeration-heat solution, convinced the contest jury of its energy-savings potential. The Energy Enhancer raises exhausted heat—which is often dissipated into the environment without being used in conventional refrigeration units—to a higher temperature, where it becomes useful energy. This can eliminate the need to produce heat by gas-fired, hot-water heaters or steam generators. The solution uses an ammonia heat pump to raise the temperature of the heat exhausted from refrigeration compressors (originally emitted at about 35°C) to a level of 80°C, which can be effectively used as a heat source for processes throughout the plant. This enables efficient use of heat in, for example, milk pasteurization, French fries production (blanching) and meat processing (cleaning machines). The heat can also be used anywhere else it's needed, such as in heating the plant's environment. This enables not only significant reduction in operating costs, but also leads to a large reduction in CO_2 emissions.

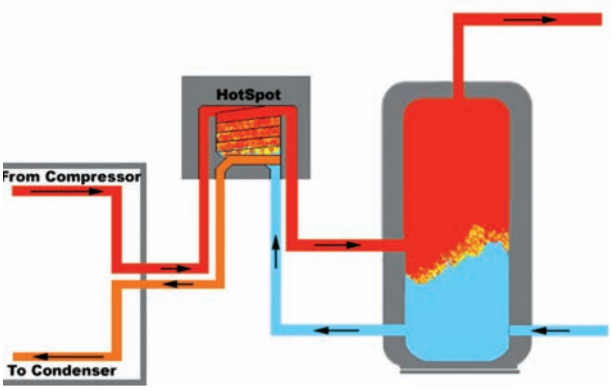
Waste heat recovery system for domestic refrigerator

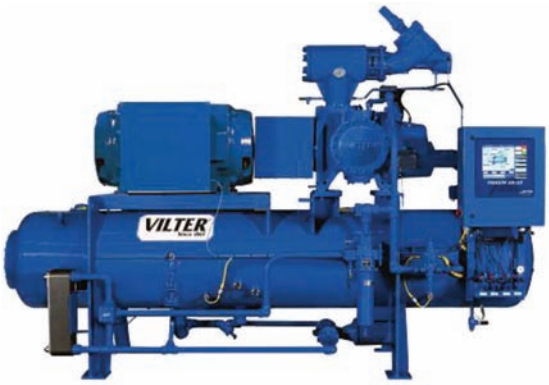
An attempt has been made to utilize waste heat from condenser of refrigerator. This heat can be used for number of domestic and industrial purposes. The study has shown that such a system is technically feasible and economically viable. Refrigerator which is been previously made exert a lot of amount heat through condenser to overcome this wastage of heat. This heat is utilized for heating water. A standard topology shows the unit connected to an existing hot water tank (pump, controls & special fittings are not shown). The unit uses the recovered heat to keep the water temperature above the tank's thermostat set-point so that the tank heating element or burner does not need to operate. Hot refrigerant gas from the compressor enters and flows in the opposite direction as the water flow.

The water picks up the heat from the refrigerant gas, cooling the gas and heating the water. The excess heat that previously would have been thrown away by the condenser is recycled. The remote unit mounts outdoors (or indoors if desired) and will usually be installed on an exterior wall somewhere near the compressor. There are two pairs of inlet/outlet connections on the unit. One inlet/outlet pair is for the compressor side, the other pair is for the hot water side. Inside the unit is a small pump, sensor controls and a double helix all-copper vented double-wall heat exchanger that transfers the heat from the refrigerant (compressor side) to the hot water side. The system connects to the compressor through standard refrigeration lines, and connects to the hot water tank through standard insulated plumbing pipe, PEX etc. The pump circulates water from the tank, through the heat exchanger, and then back to the tank. The heat exchanger efficiently transfers the compressors high temperature waste heat to the water circuit of the unit. Dual-circuit units operate the same way, except they can connect to two adjacent compressors at the same time while connected to a single hot water tank.

Waste heat recovery with industrial heat pumps

Industrial refrigeration systems reject a significant quantity of waste heat to the atmosphere. Heat pumps can capture this waste heat efficiently and use it to reduce the fossil fuels consumed to heat water. Industrial heat pumps are environmentally friendly and economical, allowing end-users to make the most of their energy resources. Industrial ammonia heat pumps offer end-users a comprehensive sustainable solution by reducing energy consumption, water, waste water, CO_2 emissions and operating costs. They are environmentally friendly as ammonia is a natural refrigerant with an ozone depletion potential (ODP) of zero and a global warming potential (GWP) of zero. Industrial heat pumps provide energy conservation, by





converting the heat energy removed by ammonia refrigeration systems and transforming it into beneficial heat for use in satisfying plant hot water requirements. This source of energy is renewable as the heat is naturally occurring within food products and is made available through food preservation by the process of refrigeration, a reusable energy source. Ammonia heat pumps reduce operating costs. Ammonia refrigeration systems absorb heat from products, processes, equipment, people, building heat gains and infiltration, and then reject it as waste heat to the atmosphere through, typically, evaporative condensers. The majority of the heat delivered by heat pumps comes from the heat extracted from these cooling loads. An incremental amount of heat delivered by heat pumps comes from the electric energy consumed in converting the low grade waste heat into high temperature usable heat. An additional benefit of industrial heat pumps, applied as retrofits to existing systems, is that they add condensing capacity to systems. Industrial heat pumps divert load away from evaporative condensers, allowing existing system compressors to operate more efficiently at lower condensing pressures.

Conclusion

Heat recovery is the collection and re-use of heat arising from any process that would otherwise be lost. The process might be inherent to a building, such as space heating, ventilation and so on, or could be something carried out as part of business activity, such as the use of ovens, furnaces and the like. Heat recovery can help to reduce the overall energy consumption of the process itself, or provide useful heat for other purposes.

Waste heat recovery has emerged as an effective way of increasing energy efficiency at factories where refrigeration is crucial. Any energy savings is important because even though commonly used refrigerants such as hydrofluorocarbons (HFCs) do not deplete the ozone level as chlorofluorocarbons (CFCs) did a generation ago, HFCs still pose global warming potential (GWP). ■

China Agriculture Study Tour

China Fruit & Vegetable Import/Export Trade Fair 2014

Fresh Produce from South Arica which was exhibited at the Expo in the South Africa Pavilion

A 15 members' delegation from India representing cross section of Agriculture fields visited China during November 15-22, 2014. The delegation included prominent members from Agriculture, Horticulture, Seeds, Dairy, Agro industries and exporters, and was led by Om Prakash – Director, In ORBIT Tours Pvt Ltd, the pioneer in India in organizing agriculture and industrial tours.

The Indian delegation was welcomed by Ms. Lisa Pang, Project Director, China International Fruit & Vegetable Import/ Export Trade Fair 2014. This specialized Fresh Fruit International Show opened its doors for fresh fruit suppliers to tap the vast Chinese market. The countries that exhibited their fresh fruits included Australia, Chile, Egypt, EU, France, Italy, Malaysia, Mexico, New Zealand, Norway, Peru, Poland, Russia, South Africa, Spain, Thailand, Turkey and USA. Chinese domestic fresh fruit producers from 19 provinces of China exhibited. New Zealand was Partner Country. India did not exhibit.

Pavilions Highlights of selective Countries

New Zealand (Partner Country)

Its Pavilion demonstrated its export potential of Kiwis, Avocados, Apples, Pears and other fruits. It emphasized on its vertical integration, from tree to label.

South Africa by Fresh Produce Exports Forum

Fruits exported: Citrus, Grapes, Pomegranates, Peaches, Plums, Apricots, Nectarines & Stone Fruits, Oranges, Lemons, Avocados, Mangoes, Litchis, Blue Berries, and Raspberries.

Malaysia

Fruit products such as Fruit Jam, Fruit Drink, Premix Coffee, Mushrooms, Chilly Sauce, Durian Fruit, Pulp & Ice cream.

Australia (TASMANIA) & Egypt -

Apples, Apricots, Cherries and Vegetables Similarly there were Pavilions of many other countries.

Conferences

Conferences covered topics of Trade, Quarantine, Inspection Regulations, Import and Export policies, technologies and global trend in the fresh produce industry. Important sessions included;

- Update on Fruit Import Policies & Quarantine Regularities
- Competition or Compensation: Wholesale Vs. Chains and E-Commerce
- How to sell to China; What Russian Market need & Technology – Apple Breeding & Orchard Management.

Special meetings

Delegation held meetings with-

- China Apple Industry Association
- Australian Table Grape Association
- Cherry Growers of Australia
- South African Blueberry Growers Association
- Green Source Packaging Technology Co. Ltd.
- Shanghai Long Wu Fruit & Vegetable Wholesale Trading Market Co. Ltd.
- Peru Citrus Growers Association
- New Zealand institute for Plant & Food/Research
- Egypt Agricultural Products – EGeT
- Euro fresh Distribution.

Many countries are aggressively marketing their fresh produce in China. 40 fresh produce products have made their way into China market and 80 more products from many countries are waiting China Govt's approval to enter the Chinese market. Many fruit processed products such as Jam, Jelly, Dry Fruits, Nuts were also exhibited.

In ORBIT's delegation at the China Fruit & Vegetable Trade Fair 2014

Packaging – an important tool for exports

Protective packaging and cold storage for fresh produce was the key to increase the share in the export market. The delegation members felt that Indian fresh produce exporters must improve the packaging to match international standards in consultation with APEDA. The services of Indian Institute of Packaging can be involved in this respect. Improved packaging can help to reduce wastage of fresh produce and encourage importers of Indian fruits & vegetables.

Cold Storage

India needs to improve the Cold Storage Infrastructure to reduce the massive wastage of over 25% of its valuable perishable produce of Fruits & Vegetables. This wastage in post-harvest is the result of combined lack of Cold Storage, Cold Chain and Refrigeration facilities from "Farm to Client". India ranks as the second largest producers in the world after China.

Visit to Beijing Xinfadi Agriculture Products Wholesale Market

Hundreds of trucks loaded with Fruits & Vegetables neatly stacked were in the market. The fresh produce was packed in printed Corrugated Boxes and individual fruits covered with thermacol nets was a new experience and exporters from many countries.

Packed Potatoes being transported at the Xinfadi Wholesale Market in Beijing

International Market

Alongside the Wholesale Market, an international market with permanent stalls of various companies from many countries showed their presence in Chinese markets. The Indian delegation members discussed with many producers. Beijing Watermelon Museum is specially incorporated to spread the watermelon history, culture, and technology, display China watermelon industry's achievements in production and scientific research, strongly boost China watermelon industry's development. In the museum there are materials on the watermelon's origin and spread, watermelon varieties' cultivation and planting and management technology, & watermelon exploitation and watermelon culture' development.

Wateremelons being moulded

Square Watermelons

Visit to Modern Agriculture Development Zone in Shanghai

A special visit was arranged for Inorbit delegation to visit Shanghai Sunquiao Modern Agriculture Joint Development Co Ltd. The In ORBIT delegation thoroughly enjoyed the educative and technical study visit. The Farm visit was based on building Factory farms with modern science and technology and developing agriculture with modern facilities. The farm was principally guided by hi-tech bio-engineering and facilities in processing agricultural products. The visitors found this visit most interesting and added to their knowledge about Chinese hi-tech farming facilities. The various Agricultural Cultivation zones are:

- Agricultural Museum

- Technique of Tissue Culture
- Orchard picking area
- Plantation of Phalaenopsis
- China Greenhouse
- Holland Greenhouse
- Agricultural Science & Technology Park
- Fruit picking area
- Desert Plant Park
- Ganoderma Lucidum Museum
- AgriPheno, High Throughput Plant Phenotyping Service Platform AgriPheno
- Soilless Culture Park.

The Indian delegation also visited the commercial cities of Beijing, Shanghai, Wuxi & Suzhou. China Agriculture Study Tour motivated Indian visitors to look beyond India to market their produce in other countries. The members felt that the Agriculture Products Market Producers of all Indian States should visit such Fruit & Vegetable Fair and markets of China, which can enlarge their vision to increase their share from the global markets. ■

Om Prakash,
Director-In ORBIT Tours ex-Chairman Travel Agents Association of India (W.R.)

Innovations to reduce energy deficit in India

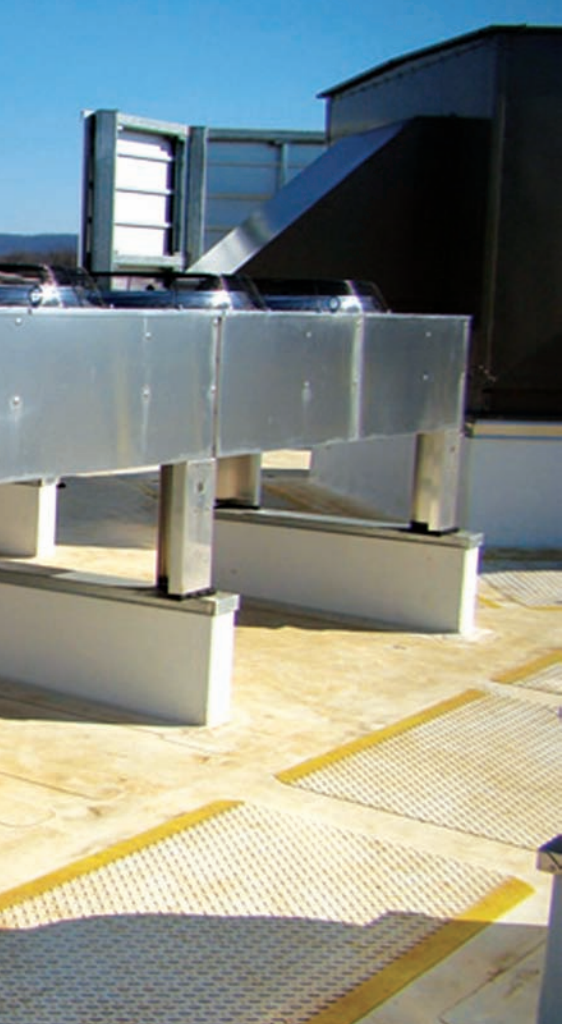
In India, increasing demand of electricity and shortage of power supply leads to frequent power outages. In 2012, the country saw a massive blackout in the entire northern region, owing to uncontrolled electricity consumption. Coupled with skewed supply demand ratio of electricity, high temperatures continue to grapple India.

The national capital faced a record high temperature of 45.1° C this year. To maintain a cool and comfortable environment in offices, malls and households, huge investments is being done for installation of Heating, Ventilation and Air Conditioning – HVAC systems. HVAC accounts for 60% of power consumption during working hours. Reports indicate a 15 % increase in demand of HVACs by next year (PTI, HVAC market to touch Rs 20,000 crore mark by FY16, 2014). It is projected that given the present situation, India is likely to experience a power shortage of 5.1 % compared to the demand, in current fiscal year. (PTI, India likely to see over 5% power shortage this fiscal, 2014).

Various Challenges that strains the power sector in India

- Sweltering heat
- High electricity demand during office hours
- Load Shedding during peak hours
- Increase in HVAC systems

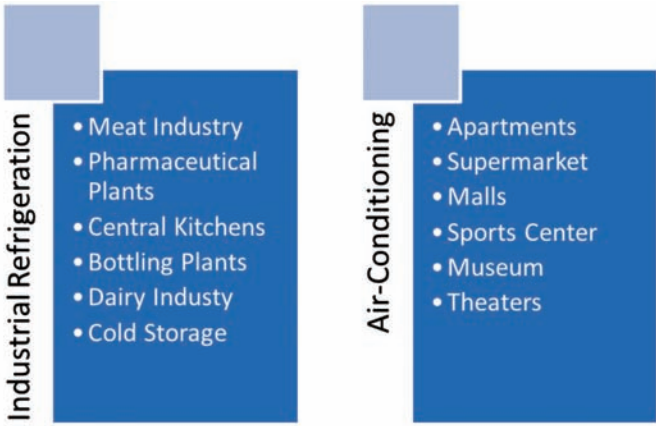
In a country with a population of



Vishnu Sasidharan, BE in Mechanical engineering from Visvesvaraya Technological University, Bangalore and MBA from S P Jain School of Global Management, Dubai/ Singapore. He has over 6 years of experience in marketing, designing and application of thermal storage systems. He is currently working with Pluss Polymers Pvt Ltd., heading the Business Development for Phase Change Materials.

Paramjot Singh, holds an Integrated MTech Degree in Industrial Chemistry from IIT (BHU), Varanasi. He is associated with Pluss Polymers Pvt Ltd., as an Executive Product development. He is currently developing products based on Phase Change materials in sectors pertaining to cold chain, pharmaceutical transport other related applications.

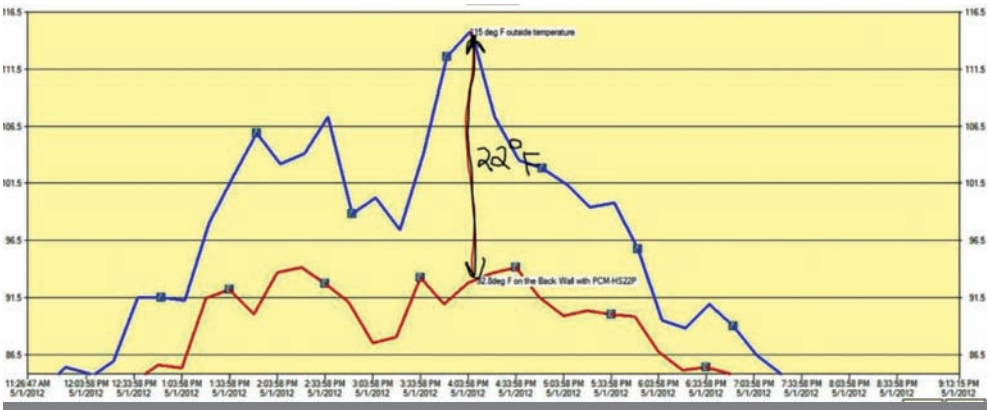
1.2 billion, it is very difficult to produce enough energy to pacify the electricity consumption. The Economic Times cited National Load Dispatch Centre that the country faces a power shortage of 4500 MW (ETbureau, 2014), and further attributing the shortage to long summer condition, high demand of electricity and scarcity of coal. This has struck small scale industry the most, which does not have enough capital to run Diesel generator to provide power backup. To deal with this energy deficit, the government has implemented new differential tariff schemes in few states. This means that the electricity would be charged at higher than standard rates during peak hours, when the consumption is maximum and at lower rates during hours of low demand. This would help deal with the economic challenges for investing in more resources. However, due to limitations in availability of natural resources, this alone would not suffice in dealing with the demand – supply imbalance. Innovative technologies and use of non-conventional resources are to be implemented along with the government policies. Phase Change Material is one of the novel materials that helps ameliorate the burden on energy consumption. In developed countries, like Europe, US, and UK, Phase Change Materials find extensive applications in the energy sector. In India, Pluss deals in Phase change materials and provides innovative solutions and versatile products using PCMs.



Phase Change Materials are thermal energy storage chemicals that can store heat energy in the form of latent heat .It needs to be charged at a particular temperature , at which it changes its phase from solid to liquid or vice versa . During discharge, it releases the stored thermal energy while maintaining a constant temperature. It does not require a constant power source and can provide passive cooling at a variety of temperatures. Pluss provides PCMs that cater to a wide variety of temperatures ranging from -33 ° C to +89 ° C and find its application in providing passive cooling solutions in textile Industry, HVAC, Buildings etc.

Passive cooling in buildings using PCM

One way of utilizing the potential of PCM in cooling of buildings is by directly incorporating the PCM tiles in the ceiling. Form stable PCMs are PCMs bound in a polymer matrix and, as the name goes, remain in a solidified stated state irrespective of whether it is in liquid phase or solid phase. The form stable materials are molded into tiles and suspended as false ceilings. How this works? During office hours, when Air condition system is on, the tiles gets charged by releasing a lot of heat with a few hours and is ready to absorb the



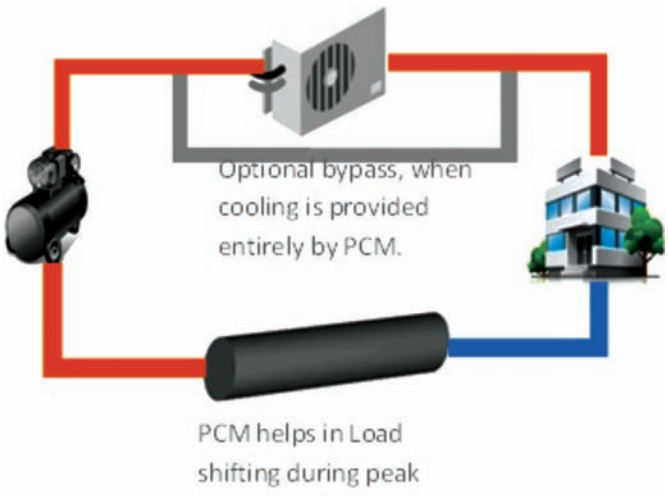
Graph to illustrate the difference in temperature fluctuation before and after the incorporation of PCM

surrounding heat . In an event of electricity outage, the PCM tiles help in keeping the surrounding cool by passively absorbing the heat. This is known as "discharging " and this would impact the environment inside the room by reducing rate of temperature fluctuation due to the outside ambient or indoor loads. For instance the application of PCM here would indirectly reduce the load on the HVAC by increasing the period between the compressor cut-in and cut-out. The graph below illustrates the difference in the temperature fluctuation before and after the incorporation of PCM which is approximately 22 ° F.

Application of PCM in large industries, malls, airports to use Thermal Energy Storage

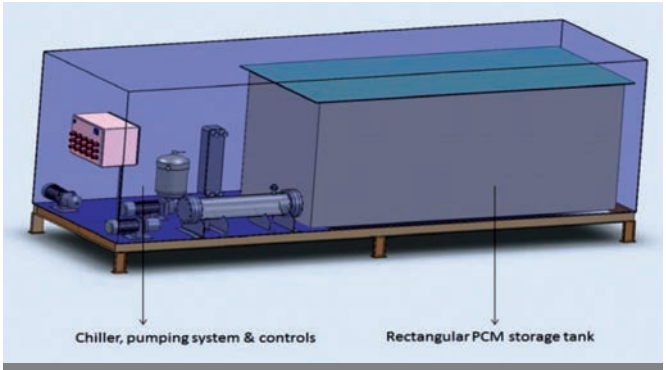
Introduction of differential tariff rates in Industrial & commercial Sector in some states in India is a means to reduce the power loads during peak hours thus reducing the instances of load shedding. The difference in tariff and lower contractual demand charges are an attractive incentive for the customer to use Thermal Energy Storage systems.

Thermal storage system is an answer to alleviate the stress of high peak load on the power generation plants. To enable peak shaving, PCMs are used in large containers known as thermal storage tanks. The coolant that flows through the tank charges the PCM during off peak hours at night. During day, the HVAC load is shared both by the TES system and the active cooling unit. This enables downsizing of the capacities of chillers, condensing units, pumping systems, cooling towers and other auxiliary equipment. Overall this improves the long term efficiency and COP of the HVAC system. For existing infrastructure that needs expansion, TES systems can help in augmenting the capacities without needing to increase the cooling units.



Case Study: Use of PCM in HVAC systems at Pluss

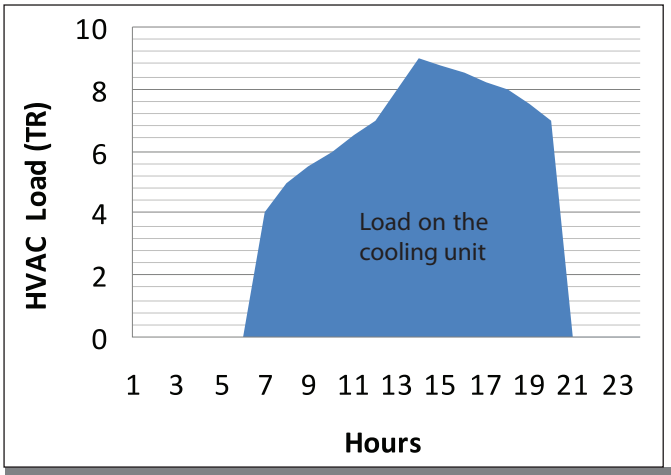
Pluss has incorporated the usage of Phase Change Materials in its HVAC system in its own factory located in Bawal to reduce the cost of power due to running of the diesel generator. The PCM is encapsulated in flat plate and positioned inside the Thermal Energy storage tank of 40 TRH capacities. The flat plate panels are used as it provides a

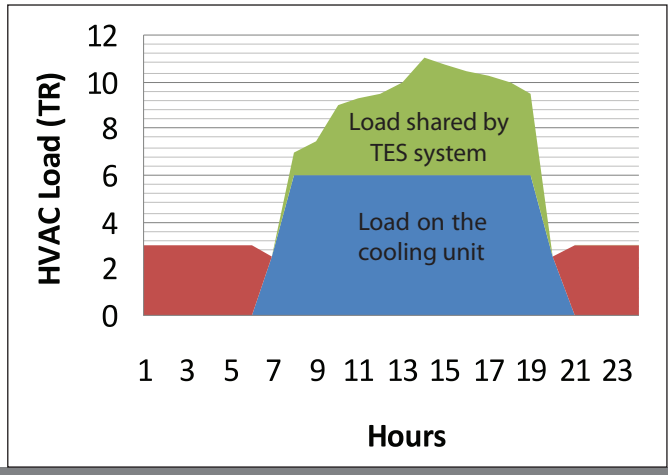


Schematic Representation of Thermal energy storage system installed at Pluss

40 TRH flat plate TES system installation at Pluss

better packing efficiency than spherical nodules encapsulation. The PCM used is savE® HS 01 which has phase change temperature of 1°C. PCM inside the encapsulations is charged by using brine solution at which is generated by a 6 TR chiller. The brine solution circulates through the TES tank and the PCM is charged during the night, at off peak hours, when electricity is available.





Comparison to show the load sharing by TES system at Pluss, during peak hours

The graph herein shows a comparison of the amount of HVAC load distribution with and without the PCM. PCMs have enabled the downsizing of the cooling unit from 9 TR to 6 TR. The balance 3 TR is produced and stored during the night (as shown by red area in Fig 4.) to take care of any additional load above 6 TR and it can be also controlled to run 100% on PCMs for up to 4 hours during power failure. With increasing population and booming industrialization, the demand for power is going to rise and rise exponentially. Natural resources are limited in quantity and serious thoughts by industry leaders and government administration is required to these resources. Innovative technologies comes handy in not just augmenting the viability of sustainable use of resources, but also helps reduce carbon emissions and noise pollution by eliminating use of Diesel Generators. ■

Adding new products based on Industry trends

Pradeep Naik, *COO, Mark Bimetal Processing Pvt Ltd, in an exclusive interview with* ***Cooling India*** *says, we source raw materials from domestic mills having global quality standards.*

Mark Bimetal Processing Pvt Ltd, is a leading manufacturing company, supplying key parts & assemblies for HVAC Products in India as well as exporting components to Netherlands. They are strengthening infrastructure in multifold direction with fully automatic work stations.

What is the contribution of Mark Bimetal Processing Private limited towards HVAC industry?

We have recently started in July 2014. But prior to this, we developed various sheet metal parts & other assemblies to HVAC industries around Pune & exported to European countries.

What is the responsibility discharged by you while being in-charge of various activities in the company?

We focus on customer's design & drawings, applications, delivery schedules; understand customers' requirement & deliver up to the standard with global Quality.

Could you share with us what are the core parts that you are developing for HVAC? Also from where are you buying the material?

To start with, we have already developed various types of Copper material required in Coil, Manifold assemblies. We source raw materials from domestic mills having global quality standards as well as import from European Supplier.

Do share with us range of company's products available in the market?

Yes, we manufacture various types of Copper Bends & Headers (Manifolds).

Could you elaborate upon the export activities and expansion thereof? To which countries do you export your HVAC products?

We are developing various customers in UAE, Europe & Russia. All theses are in development & approval stage. Also, we are developing Domestic customeras per their needs.

Share something about heat transfer technology and how suitable it is for India and globally in terms of market demand?

It is basically thermodynamic process with effective use of proper refrigerants in well defined closed loop environment. For India if we consider food industries, there is huge potential, our wastage of food & other things are huge. This is more than 45% due to non availability of such infrastructure but, this is not authentic figure. In terms of global demand when we -as India- do our planning to expand and if sources/ market need has huge difference means there is huge demand. One has to go to customers to create awareness how HVAC can save their product & improve the product life from the same field in various small groups.

Could you state about Quality Management System and standards being followed in your company?

We are in process of implementing following systems in phased manner, and this is under preparation.

What are the parameters you adhere to while manufacturing various accessories and components for application in HVAC industry?

It is exactly the raw material input from customer end on application base apart from specifications from end customers.

Are there any plans to further add new product range or the projects and what development would you like to suggest while in the market?

Definitely, we will add new products based on Industry trends. We are working on continuous base on long term perspective.

Where would you envision the company in the next two years?

In next two years, we should be able, as a reliable supplier to provide to the HVAC industry a totally approved product range in Tubular Components. ■

A Book on Internal Corrosion of Pipelines

A book entitled 'Internal Corrosion of Pipelines' written by Dr Anil Bhardwaj and Baldev Raj, was released on November 14 during International Conference and Expo CORCON 2014, held November 12-14 at Hotel Grand Hyat. The book was released by Sekhar Basu, Director, Bhabha Atomic Research Institute. The book 'Internal Corrosion of Pipelines', dwells upon various factors responsible for internal corrosion of pipelines, which include corroding gases like O_2, CO_2, H_2S; different types of bacteria; environmental factors such as temperature and pressure; aqueous chemistry including salinity, buffer ion concentration, ionic composition and pH; flow regimes in case of multiphase flow etc. Mechanisms, causes and effects have been explained in user-friendly language with apt case studies and examples. Internal corrosion of pipes in seawater environment is a very specific issue relevant to coastal, offshore and shipping industry. The options of corrosion resistant materials and corrosion control have been elaborated which can vary depending upon requirement of industry, temperature and flow conditions. Two types of pipeline systems are common to most chemical process industries, viz. cooling water and firewater. They are essential for efficient and safe operation of a chemical process plant. The environmental and flow conditions are different for these lines and unique corrosion control measures, including specific materials of construction, for these two categories of lines have been dealt in this book in separate chapters. A discussion on composite materials has also been included, which are fast emerging as corrosion resistant materials for several environments of pipelines. Corrosion control and monitoring go hand-in-hand and therefore, the aspect of corrosion monitoring and inspection has also been duly covered in this book. Finally, there is a chapter on holistic approach to handle corrosion through corrosion management tools. The chapters have been written by experts in the respective fields. Certainly, this book will be a treasure for all those involved with pipelines in variety of environments of various industries. Its readership target is Professional, Researcher, Undergraduate and Postgraduate Students. The Editors of the book are: Anil Bhardwaj General Manager (Chemistry), Oil and Natural Gas Corporation Ltd. (ONGC) and Baldev Raj, Director, National Institute of Advanced Studies, Indian Institute of Science Campus, Bangalore. Sized 185mm x 240mm, it comes in paperback edition with 372 pages and carries ISBN No. as 978-81-8487-413-6. ■

Seen from L to R: Sekhar Basu, Director BARC and Dr Anil Bhardwaj, during book launch at CORCON 2014

HVR award for TurboChill FreeCool Chiller

British cooling systems manufacturer picked up a further commendation for its TurboChill™ and TurboChill™ FreeCool chiller (200-1830kW) for 'Sustainable Product of the Year' in the 2014 HVR Awards following on from this year's DataCenter Dynamics at London Excel which saw a record-breaking number of visitors to the Airedale stand. The first BSI approved chiller with low GWP refrigerant R1234ze, the TurboChill FreeCool provides industry-leading energy efficiency per footprint available from a centrifugal-based chiller with the capacity to deliver up to twice as much free-cooling as an equivalent thermosiphon system. The TurboChill FreeCool incorporates the ability to supply fully concurrent free-cooling, without break of supply, during the transition from mechanical cooling, unlike equivalent thermosiphon designs. This increases energy efficiency by reducing the need for mechanical (DX) cooling and maximising the part-load efficiencies of components such as EC fans, inverter-driven pumps and centrifugal compressors. The addition of low GWP hydro-fluoro olefin (HFO) refrigerant R1234ze makes the TurboChill a highly sustainable cooling alternative which automatically receives two BREEAM points in recognition of its low global warming impact. Rated by the Intergovernmental Panel for Climate Change with a 100-year GWP lower than 1, better than CO_2, R1234ze will break down within just 16.4 days; in contrast R134a has a 100 year GWP of 2088 and takes 14 years to break down. Airedale Technical Director, George Hannah, said, "The TurboChill with R1234ze provides the market with a low GWP chiller alternative well ahead of the impending EU phase-down in the use of HFCs. This is likely to see reductions in the supply of the most important F-gases that can be sold in the EU from 2015 onwards and their phasing-down in steps to one-fifth of 2014 sales in 2030. The TurboChill with R1234ze is also shortlisted under 'Environmental Initiative of the Year' and 'AC Product of the Year' in the 2015 ACR News Awards due on 26 February. ■

Cooling Technologies for Air Conditioning Systems for Enhancing Energy Efficiency

This article explores the various technologies for enhancing the energy efficiency and reducing the electrical energy consumption of central air conditioners. The new energy reducing innovations in technology are the variable refrigerant flow and inverter driven compressor motors.

Apart from these, for matching the system load and minimizing the power input mixed mode air conditioning (change over from compressor operation (vapour compressor) & blower operation (sensible cooling), ice build/melt cooling energy storage, roof top solar photovoltaic power and integration of ice based cooling energy storage to roof top give significant reduction in energy consumption of the systems by over 60% of the original energy consumption.

Central air conditioning systems can be classified as follows:

Power supply

- Active systems (vapor compression cycle).
- Passive cooling systems (natural ventilation through windows, chimneys, etc.).
- Mixed mode systems (combination of active and passive systems).

Energy source

Conventional electrical source; Roof top Solar PV; Wind generators; Diesel sets & Time wise mixed source of energy

Energy storage

- No storage and used with availability of energy source
- Diesel set with diesel storage tank
- Battery storage for electrical energy
- Thermal storage (cooling effect)
- Chemical storage (H_2 storage).

Mode of transfer of cooling effect

Refrigerant (variable refrigerant flow), Chilled water and Chilled air

Energy efficiency of conventional AC plants

Indices are both inherent (machine dependent) & installed (dependent on both machine & its operating environment).

Three inherent indices of energy efficiency are:

- SP (Specific electric power) (kW of electric power input per tonne of refrigeration = kW/TR) (1TR=3.516 kW)
- EER (energy efficiency ratio) = cooling load (kW)/electric input (kW) which is expressed on the basis of p.u., it is generally in the range of 2.3 to 3.1.
- Coefficient of Performance is given by the ratio 3.516/SP

The above three are interrelated. The installed energy efficiency index is the SEC (specific energy consumption) in kWh/m^2/year or in kWh/TR/year. As per the Energy Conservation Building Code of India, the energy efficiency of buildings must be within 120 kWh/m^2/year for AC buildings & 25-40 kWh/m^2/year for non AC buildings. The AC contribution can be taken as 80-90 kWh/m^2/year. The AC power is bench marked at 25 W/m^2.

To compute the specific energy (kWh/TR/year) from specific power rating (kW/TR), the on time to total time ratio is ratio of the period under which the AC plant is in operation and drawing full active power to the total time period under

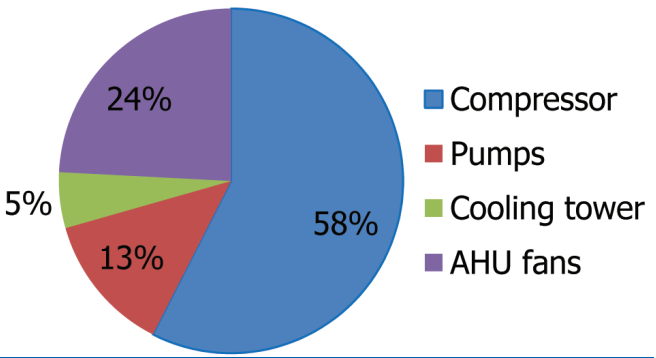


Fig. 1: Break up of electric power (%) of a chiller system

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consideration (24 hours/ day; 720 hours/month or 8760 hours/year). This is a temperature dependent factor and is designed to be around 0.3 for the of ambient temperature of 33-34^{O}C and is reduced to zero when the ambient temperature coincides with conditioned air temperature.

The break up of the power input to a typical central AC plant is given in Fig. 1 while the break up of

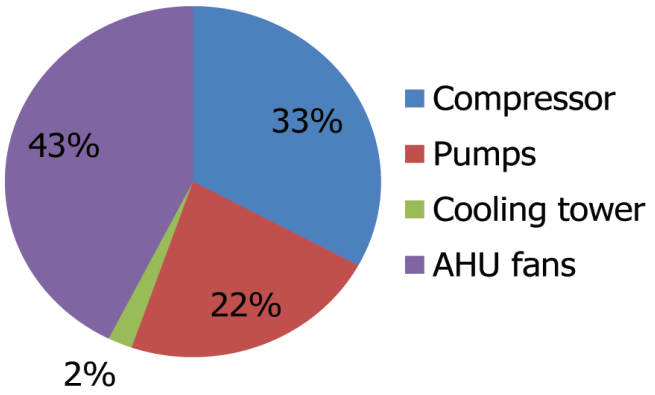

Fig. 2: Break up of electrical energy (kWh/year) of a chiller system as %

the energy is given in Fig. 2. It can be seen that over a period the AHU fans consume higher amount of energy than the compressors.

This leads to an inference in many AC plants that though the primary power plant (vapour compression circuit) is more energy efficient than window or split ACs, inefficient distribution of chilled air can lead to higher energy consumption and offset the gains of a central system. This is also borne by experience. The distribution efficiency of chilled air tilts the energy efficiency of ACs.

Variable refrigerant flow technology is another way of minimizing the chilled air losses by taking the refrigerant to the load point thereby minimizing the transfer through the chilled water or chilled air.

Variable frequency drives for capacity control of AC compressors

The developments in the technology of VFDs have been used effectively to develop capacity control of the compressors by varying the speed of the compressor (and hence its cooling output) based on programmed patterns. VFDs provide excellent source-load tracking. 32 bit RISC microcontrollers for compressor and fan motor control has shown energy savings as well as increased energy efficiency of the power board/driver to over 94-95%. While integrating SPV power with AC compressors, VFDs are essential to restrict the starting transient current and power to acceptable level.

Choice of compressors for central plants

Table 1 gives a brief picture of the types of compressor power plants. While air cooled compressors are inherently inefficient (COP below 3.0) & restricted to only small capacities only water cooled compressors are of use for energy efficient operation. Amidst the water cooled systems large reciprocating compressor technology is on the way out because of more energy efficient options. Screw compressors are preferred for better part load characteristics in the capacity range up to 200 TR while for smaller capacities scroll compressors are used. For very large capacities of 300 TR to 1500 TR (single unit) centrifugal units are in use.

Sl. No.	Water cooled electric driven compressors	COP	SEC (kW/TR)
01	Reciprocating compressors (presently on the way of phasing out except for very small sizes)	4.0-4.2	0.80-0.85
02	Centrifugal compressors (500-1500 TR)	5.0-5.6	0.55-0.60
03	Rotary screw (50-200 TR) and scroll (5-50 TR) compressors	4.9-5.5	0.65-0.70

Table 1: Energy efficiency of various types of compressors for central plants

Centralized AC Vs unitary split ACs

Though these central compressors are far more energy efficient than their reciprocating counterparts, thermal management of the chilled air through the air handing units (AHUs), cold ductings and return ductings play a sizeable role in determining the annual energy consumption- so much so that the energy efficiency can fall below that of the very small reciprocating compressor based unitary and split units in certain cases. The split ACs have SECs way above the centralized ACs. However, the central ACs which have large losses of chilled air and chilling of the AHU room due to lack of communication between the conditioned space and the chilled water flow over the AHU, result in high losses in the AHU fan power, thereby upgrading the energy consumption of the central units. In cases where there is poor communication between the conditioned air space and the chiller plant, split ACs seem to have an upper hand from the point of view of energy

consumption owing to their on demand operation, efficient thermostatic controls and nearness of the unit to the load centre. Hence, a judicious choice of the AC plants needs to be done- either through superior control over the AHUs of central units or to go in for unitary systems on a need basis.

Mixed Mode Air Conditioning Systems

Active AC systems are energy intensive whereas passive systems have low energy intensity. However, passive systems are limited in their capability to deliver cooling effect under all operating conditions of temperature and relative humidity over the whole year.

Passive cooling can be achieved in a variety of ways:

- Ventilation through window opening-can be driven by wind on one single side or to cross ventilation
- Stack ventilation through ventilation boxes connected to multi-storey chimneys, roof vents, structural fins, under-floor ducts, etc.
- Using the room as a chimney by drawing in fresh air at a low level and exhausting it at the top.
- Atria for variant of stack ventilation, where multi-storey volume created for circulation & cross ventilation across rooms.
- Evaporative cooling

Passive cooling or natural ventilation has the advantages of:

- A sustainable cooling solution.
- Good fresh air supply.
- Low energy and maintenance costs.
- Free night time cooling.
- More usable floor area due to less lower sized or no active AC system.

The zero energy building concepts are showing trends of turning into a design reality. Thermal simulation models are meeting the design requirements of achieving zero net energy in buildings. Evolutionary algorithms have been used in solved constrained building design problems for achieving near zero energy buildings. The role of ambient energy in comfort AC design of buildings has increased in the level of reliability to provide bankable solutions for year round performance.

On the other hand active systems have the advantages of:

- Ideal control over indoor air temperature under all weather conditions.
- Possibility of ice energy storage systems for peak power storage management.
- Optimal energy efficiency at low loads through variable frequency drives (VDFs).
- Energy savings options with cold recover wheels and heat recovery system.

In MM-AC, natural ventilation is used as the primary means of providing cooling which is then topped up by active vapor compression cooling. MM-AC are generally classified based on the technique of natural and the operational mode as:

- **Contingency Mode:** Here both systems are independently installed- active & passive separately and switched over by the end user. They are not mutually exclusive.
- **Zoned Mode**: Here a certain zone of the building is fitted with active system & another zone is based on passive systems.
- **Complementary Mode**: Here both systems are provided in the same zone. Operation is either mutually exclusive or simultaneous. There are three modes of complimentary operation:
  - Alternating operation
  - Change-over operation
  - Concurrent operation

MM-AC strategy brings together the benefits of both active and passive systems to provide:

- Low energy intensity, Low operating costs.
- Accurate conditioned air control.
- Improved comfort through inclusion of inherent air change.
- Better tunability of the capacity to match the load.

MM-AC have the inherent advantage of balanced cost, balanced energy consumption & balanced energy efficiency as compared to the active systems. MM-AC designs are limited in present usage because their design principles are not well exploited in all cases. However, a good level of success has been achieved towards the development of MM-AC plants. MM-AC hybrid variations have been adopted for reducing the electrical energy requirements of building AC. Low energy buildings based on MM-AC have been design to meet the standards of comfort. A review of technologies and strategy to improve energy efficiency of MM-AC plants indicates that fuzzy, predictive & adaptive controls are successful. A primitive parts model (considering the basic heat and mass transfer) has been successfully used to match & map complex building topologies.

Evaporative cooling & hybrid storage have also been integrated into MM-AC systems for achieving better comfort conditions. Ventilation has played a major role in the effective implementation of MM-AC. Under floor and overhead air distribution; displacement ventilation and chilled ceiling have been used for MM-AC of commercial buildings. Monitoring, controls and fault diagnostics of ventilation are vital for effective implementation of MM-AC systems. Controls for MM-AC include expert systems, energy flow controls, logic based controls, fuzzy logic based controls and capacity controls based on economics. Temperature zoning also plays a role in improving energy efficiencies of MM-AC systems.

With the use of MM-AC aided by design support, controls and temperature zoning, the projected saving in energy or the energy efficiency based on paid electrical energy can be reduced by 40 to 50% without sacrificing comfort. This paper discusses the design aspects of MM-AC plants for large scale AC plants for conditioning of Malls, working spaces in IT halls, sitting areas in large office complexes, etc., where the use of ambient energy via ventilation fans can bring about increased energy efficiency.

New generation controls based on intelligent shifting between the compressor and the fans

This is a three element control of ambient temperature, conditioned space temperature and the set point temperature. The logic is that if the ambient temperature is lower than the conditioned space temperature, then the air fans will be energized and the conditioned space will be cooled (sensible cooling) through the ambient air. This process will continue

until the ambient temperature and conditioned space temperature are equalized. If the set point temperature is lower than the conditioned space temperature after equalization of the ambient and conditioned space temperatures, then the compressors will operate. This scheme improves the energy efficiency of the overall system because the power rating of the blower is only 0.04-0.10 kW/TR as compared to 0.6-1.20 kW/TR of the compressors. This scheme is ineffective when the conditioned space temperature is lower or equal to the ambient temperature. However, it can be modified to take advantage of the lower ambient temperatures during nights.

Fig. 3 give the ambient temperature in Bangalore for the hottest month and coldest month. It can be seen that there are lot of energy saving opportunities during the winter months through the use of air fans.

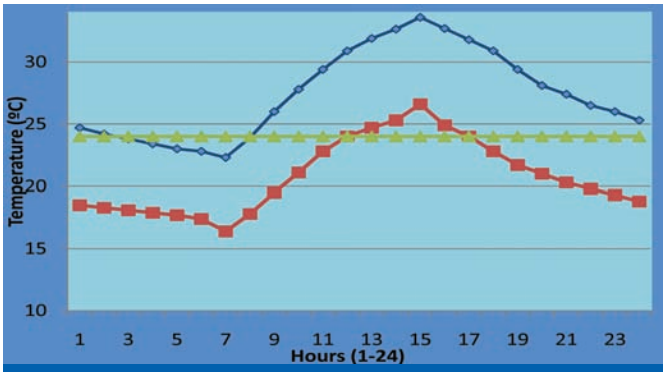

Fig. 3: Variation of ambient temperature in April & December (Bangalore) aalong with conditioned air temperature

Ice based energy storage systems

Integration of ice based energy storage systems into air conditioning plants were under experimentation or over twenty five years but only very recently good technological success has been achieved on the hardware front. The advantages of integration of conventional AC units with cooling thermal energy storage (CTES) are:

Decoupling of electric power generation pattern and the AC operating pattern.

Decoupling of time domains of chiller (or evaporator) operation and AHU (fan) operation. This decoupling results in reduced electric power input (30-40%), reduced electrical energy input (20-40%) and more effective cooling rates.

Three of the most important issues for the AC-CTES are:

- Technological feasibility
- Energy efficiency
- Capital cost and life cycle costs.

The technological feasibility has been proven for chilled water based systems from small capacity to very large capacities. Around the year 2007, AC-CTES systems below 100 TR were considered uneconomical but recent advances have ensured that even 1 TR capacity can be designed with CTES. Thus modularity can be ensured from 1 TR upto 100 TR.

Table 2 gives the power rating of a conventional chiller, AC-CTES with ice build mode and ice melt modes. There is a slight reduction in the chilled water pumps and AHU fans in the AC-CTES because of lower flow due to lower working temperatures

Water cooled chillers	Conventional	Ice build mode	Ice melt mode
	(kW/TR)		
Compressor	0.978	0.978	
Chilled water pump	0.165	0.150	0.150
Condenser pump	0.500	0.500	
AHU fans	0.649		0.50
Cooling tower fans	0.039	0.039	
System SEC	**2.33**	**1.667**	**0.65**

Table 2: Power ratings during ice freeze and ice melt processes

of chilled water & chilled air. Basically, with the use of AC-CTES the maximum power is reduced because of de-coupling chilling and AHU operation.

The specific power is reduced from 2.33 kW/TR for a conventional system to 1.68 kW/TR during the ice freeze phase and 0.65 kW/TR during the ice melt phase.

AC-CTES plant configurations

Presently there are systems with chilled water as the main cooling effect carrier to Air Handling Units which further convey the cooling effect through chilled air. Alternatively, there are systems where the refrigerant from the evaporator itself carry the cooling effect till the room where it is finally dispersed by a ventilation fan Variable Refrigerant Flow Systems).

AC-CTES systems can be configured as follows:

- Option for cooling through either Direct chiller operation (without CTES) (chilled water scheme or VRF scheme) or ice build and melt operation.
- Cooling through Ice build and melt operation only without cooling through direct chiller operation (VRF scheme is not applicable here).
    - External ice build and melt system.
    - Internal ice build & melt system.

In an ice build and melt system, the working fluid for transferring the cooling effect is a mixture of water and antifreeze agent (viz. ethylene glycol or propylene glycol) in mass fraction of 75%/25%. Methylene glycol has a specific heat of 3.77 kJ/kg^{O}C (water: 3.77 kJ/kg^{O}C) and viscosity of 3.2 mPas (water: 1.5 mPas).

In an external ice build and melt system the chilled water (plus antifreeze liquid) is part of the melt system and is exchanged between

- Chiller and the ice storage system for ice build process and
- The ice storage system and a heat exchanger for ice melt process.

A secondary fluid is used to transfer the cooling effect from the heat exchanger into the air handling unit (AHU).

In the internal ice build system the chilled water (plus antifreeze liquid) is circulated between

- The chiller and ice storage system during ice build process.
- Ice storage system and the AHU during the ice melt system.

Both systems have advantage & disadvantages and overall system can built any one concept.

Ice is formed and stored in a static heat exchanger vessel called as Ice storage tank which are characterized by their freeze rate (kW) and melt rate (kW). Under 100% capacity the ice storage contains 65% ice and 35% liquid. The storage efficiency is nearly 95%. The cold thermal loss is 1-5%/day. The

thermal capacity of ice storage systems are 1.8-2.4 kW/m3^{O}C These can operated under unlimited charge-discharge thermal and deterioration of the working fluid is not an issue. In the external ice form and melt system the ice forming liquid itself (chilled water with glycol) is circulated into a heat exchanger for transferring the cooling effect and from these it is indirectly transferred to the AHU. The circulating fluid carrying up to 15% ice does not decrease the convective heat transfer coefficient. Mixtures in excess of 15% ice retard the heat transfer coefficient with any benefit in temperature difference. In the internal ice form and melt system the chilled water with glycol is circulated in the heat exchanger tubes of the ice storage tank and the ice forming mixture is always inside the tank & is not circulated.

The power plant for the ice forming is the ice making chiller- a centrifugal chiller which is slightly different from the conventional chiller in that it has two different exit water set points. The controls are set such that the entering chilled water drops to below exit set point and operates at the maximum capacity in ice making mode. Conventional chillers respond to cooling load changes through capacity control. Figures 4 & 5 give a schematics of AC-CTES system. Fig. 6 gives a comparison of AC and AC-CTES system. Figures 7 and 8 gives schematics of external and internal ice build & melt systems.

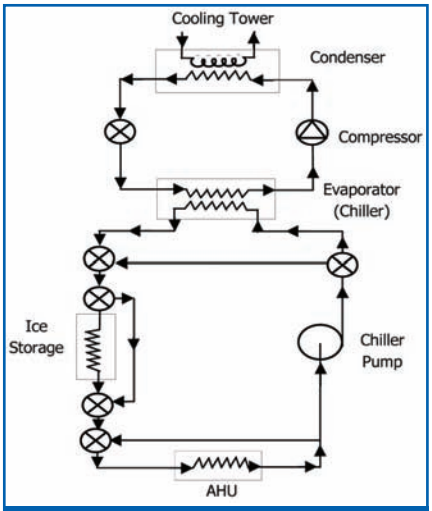

Fig. 4: View of a AC-CTES system with a provision of both direct chiller operation as well as CTES

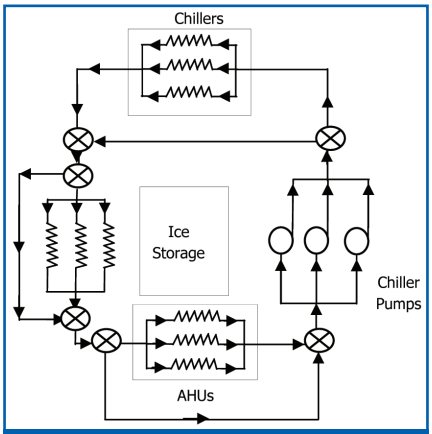

Fig. 5: Schematic of a multi-cooler AC-CTES system for provision for both direct chiller operation as well as CTES

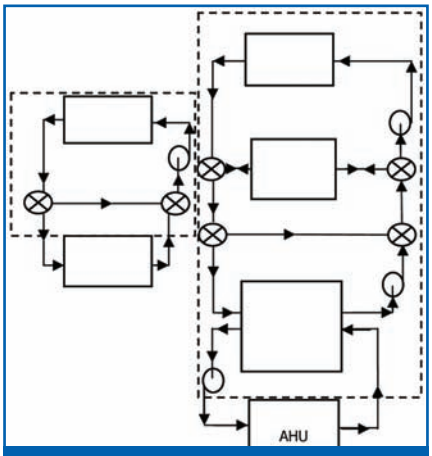

Fig. 6: Comparison of AC and AC-CTES system

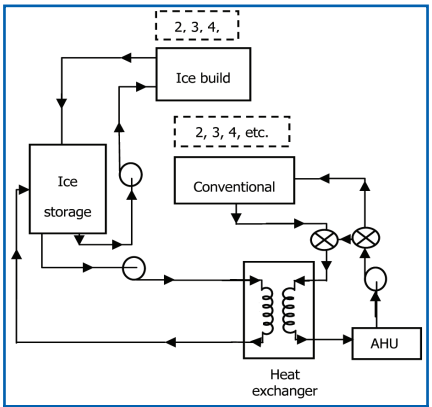

Fig. 7: External ice build and melt system

Solar photovoltaic (SPV) powered AC plants

In tropical countries like India, the SPV power generating period can be classified into three distinct phases:

- Summer season with low stochastic losses, high, regular and reliable incident solar radiation.

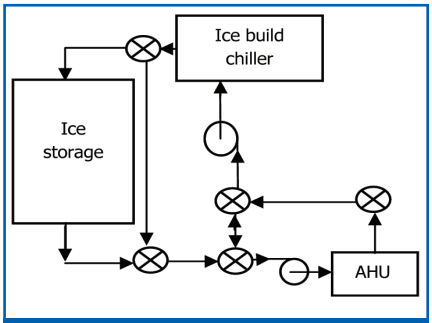

Fig. 8: Internal ice build and melt system

- Winter season with medium level of regular & reliable incident radiation.
- Rainy season characterized by high stochastic losses (due to cloudy and rainy weather) and low reliability.

Solar photovoltaic systems can provide the power for central AC plants as fossil fuel substitution options. One of the advantages of SPV power is it coincides with the commercial AC loads implying that very less electric storage is required for off grid operation. In a typical PSV plant in India the power output is 0.068 kW/m^2 of SPV panel area. The daily energy generation is 0.885 kWh/m^2. Approximately 6 m^2 of panels are required for providing 1 kW peak power. For providing 1 kW of average power over 12 hours, then nearly 15 m^2 of panels are required. Figures 9 & 10 give the curves for a typical 100 kW AC plant. The SPV peak capacity is around 160 kW. This includes not only the compressor power but also the balance of plant such as pumps, cooling tower fans, AHU fans, etc.

For a typical 100 kW system the capital cost of SPV (combination of crystalline silicon and thin film to handle the Indian weather conditions) power plant (together with the inverter, batteries, etc.) is around Rs 73 lakhs and the saving in energy is around Rs 8,760/ day which gives a pay back period of 5.5 years considering an energy charge of Rs 12/kWh. Presently, many SPV systems get paid as much as Rs 8-10/kWh in the grid tied mode due to the renewable energy obligation.

AC-CTES based on ice build and melt processes for integration with SPV

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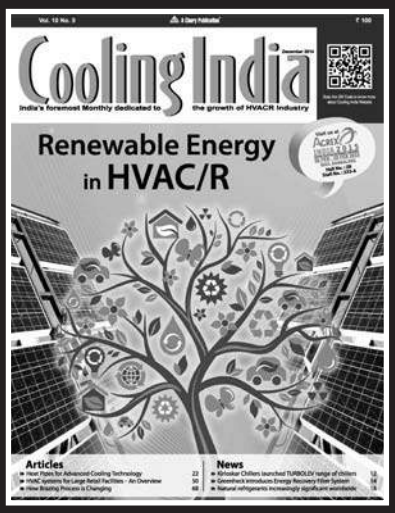

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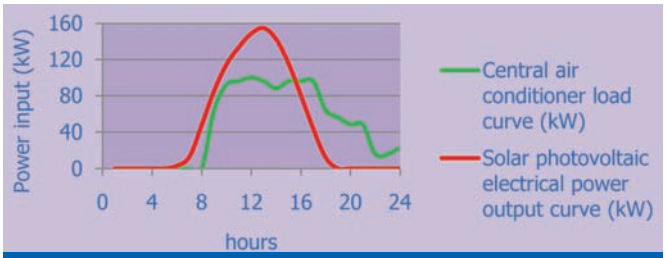


Fig. 9: Air conditioning commercial load curve

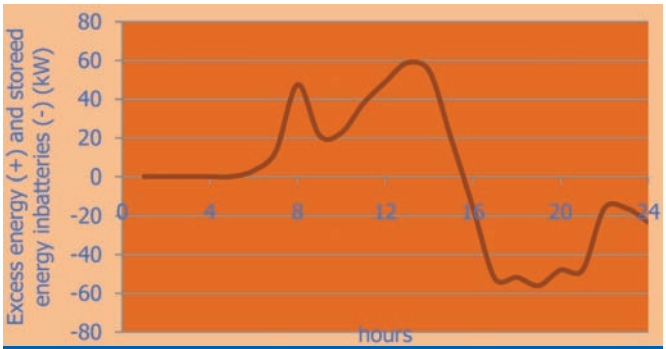


Fig. 10: Solar PV energy- excess (+) & deficient (-)

lends itself an ideal candidate energy source because AC with CTES referred to as AC-CTES is a means of balancing the mismatch between the load curve and the solar generation curve. The peak power input is critical in SPV powered plants where the plant capacity directly determines the maximum power & energy generation.

In the operation of AC-CTES with SPV the power input is reduced and also the energy consumption is lower as compared to conventional AC operation. In grid power operation, the non-peak period can be used for ice free processes.

SPV power is available as a parabolic output and only for 12 hours in a day. For providing electrical power in the non-sunshine period, electrical energy storage is required in the form of battery banks. The energy efficiency of electrical energy storage is 80% which calls for 20% additional generation to meet the load. If the AC-CTES system is available, the storage of electrical energy in battery banks is totally avoided. Further during the sunshine period, the excess energy can be used for the ice freeze process. During the non-sunshine period the ice melt process will provide the cooling effect. With AC-CTES systems, the chilling (cooling effect generation) and the cooling effect utilization are de-coupled. As a result only those equipment associated with chilling are used during the ice freeze process & equipment with AHU operation will be used in the ice melt process. Thus the total power at any time of operation is much lower than the simultaneous chilling and AHU operation of conventional ACs. Also, the CTES can be modulated as per solar incident radiation. Table 3 gives a comparison of AC-CTES with the conventional systems.

The design criterion are:

- Avoiding battery storage of SPV power altogether.
- Total use of SPV power during the sunshine period for providing cooling to the extent required and the storage of the balance through the ice storage system for use during the non-solar period.

AC-CTES based on SPV can be operated through summer and winter (depending on the need) and with limited applicability during the rainy season.

Sl. No.	Particulars	Units	Values	
			Conventional	AC-CTES
1	100 TR conventional system maximum power	kW	233.06	233.06
2	Conventional system reduced to electrical output of 100 kW	TR	42.91	42.91 [*]
3	Energy input for 42.91 TR system	kWh	850.22	436.89
4	Average Power input over 24 h [**]	kW	35.43	18.2
5	Maximum power input	kW	100	71.72
6	Energy utilized during sunshine hours [#]	kWh	680.46	436.89
7	Electrical energy storage required	kWh	169.76	10.1
8	Area of SPV required	m^2	962.97	494.84
9	Maximum SPV power	kW	119.93	61.63

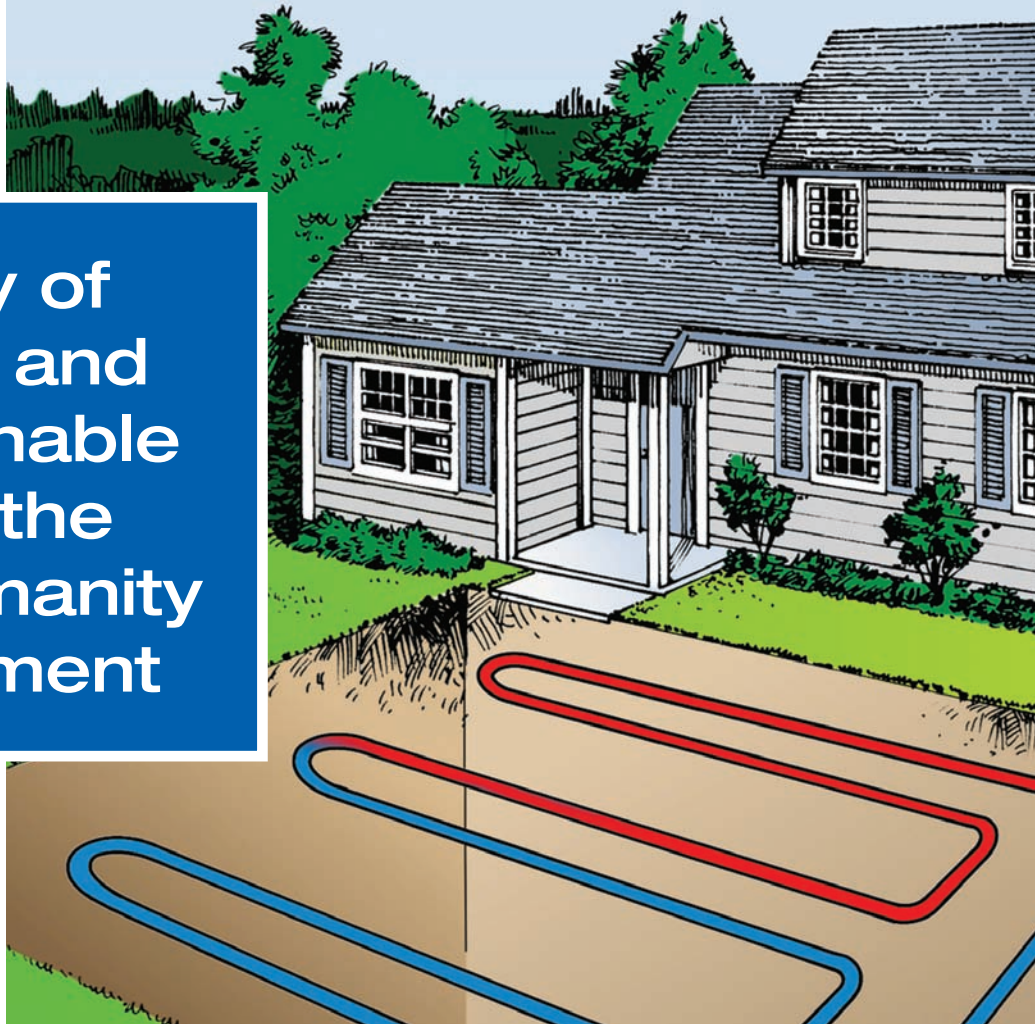
Table 3: Comparative performance of AC-CTES with conventional systems

[*] Same TR is maintained though electrical rating is reduced [**] Same as average SPV power output over a day
[#] Same as energy generation from SPV

Conclusions

- Though centrifugal and screw compressors are far more energy efficient than their reciprocating counterparts, thermal management of the chilled air through the Air Handing Units, cold ductings and return ductings play a sizeable role in determining the annual energy consumption- so much so that the energy efficiency can fall below that of the very small reciprocating compressor based unitary and split units in certain cases. This must be avoided through better control of the AHUs.
- One primary method of energy efficiency improvement in centralized ACs is to have an intelligent control system shifting between the air change with the environment & compressor operation. In stations like Bengaluru, this mode of operation can give good energy savings.
- ACs with cooling thermal energy storage in the form of ice make and melt systems are applicable when the source-load mismatch is present as it can get charged when there is electric power and discharge cooling effect when these is no electrical power. AC-CTES systems show definite reduction in energy consumption and maximum power and operating power by 20-40%. A number of commercial window and split AC-CTES products have come into the market and the technology is matured to a reliability level for wide scale usage.
- Solar photovoltaic power plants are ideally suited for operation of central ACs as the solar energy pattern nearly matches with the commercial AC load pattern thereby necessitating minimum energy storage. With the present SPV systems on the verge of achieving grid parity, these pay back within 5.5 years. For SPV operation AC-CTES systems are essential for minimizing capital costs of the source. ■

Technology of Geothermal and Clean Sustainable Energy for the benefit of humanity and environment



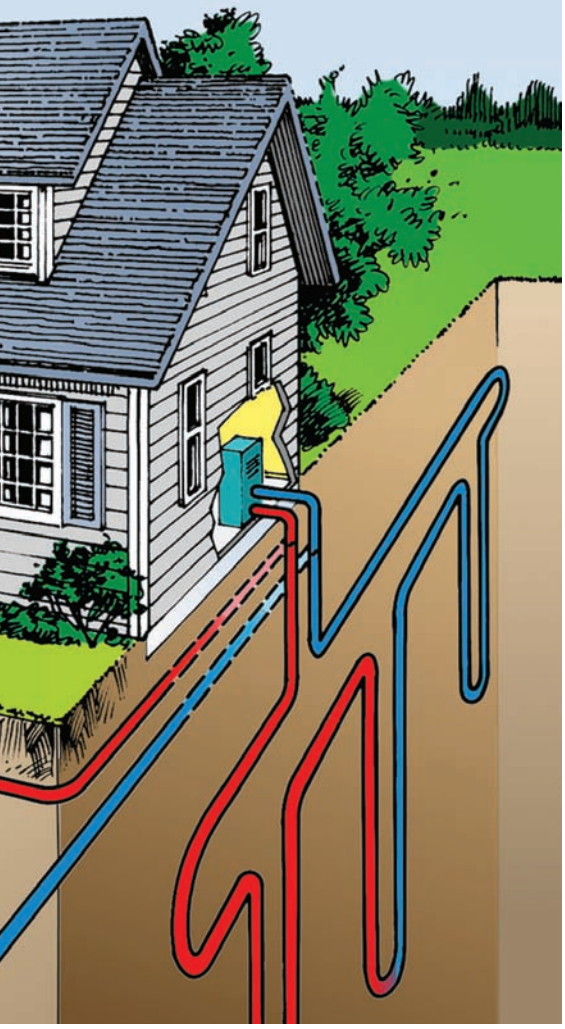
Globally, buildings are responsible for approximately 40% of the total world annual energy consumption.

Most of this energy is for the provision of lighting, heating, cooling, and air conditioning. Increasing awareness of the environmental impact of CO_2, NO_x & CFCs emissions triggered a renewed interest in environmentally friendly cooling, and heating technologies. Under the 1997 Montreal Protocol, governments agreed to phase out chemicals used as refrigerants that have the potential to destroy stratospheric ozone. It was therefore considered desirable to reduce energy consumption and decrease the rate of depletion of world energy reserves and pollution of the environment. One way of reducing building energy consumption is to design buildings, which are more economical in their use of energy for heating, lighting, cooling, ventilation and hot water supply. Passive measures, particularly natural or hybrid ventilation rather than air-conditioning, can dramatically reduce primary energy consumption. However, exploitation of renewable energy in buildings and agricultural greenhouses can, also, significantly contribute towards reducing dependency on fossil fuels. Therefore, promoting innovative renewable applications and reinforcing the ground source energy market will contribute to preservation of the ecosystem by reducing emissions at local and global levels. This will also contribute to the amelioration of environmental conditions by replacing conventional fuels with renewable energies that produce no air pollution or greenhouse gases. An approach is needed to integrate renewable energies in a way to meet high building performance. However, because renewable energy sources are stochastic and geographically diffuse their ability to match demand is determined by adoption of one of the following two approaches: the utilisation of a capture area greater than that occupied by the community to be supplied, or the reduction of the community's energy demands to a level commensurate with the locally available renewable resources.

The term "ground source heat pump" has become an all-inclusive term to describe a heat pump system that uses the earth, ground water, or surface water as a heat source and/or sink. The GSHP systems consist of three loops or cycles as shown in Figures 1-2. The first loop is on the load side and is either an air/water loop or a water/water loop, depending on the application. The second loop is the refrigerant loop inside a water source heat pump. Thermodynamically, there is no difference between the well-known vapour-compression refrigeration cycle and the heat pump cycle; both systems absorb heat at a low temperature level and reject it to a higher temperature level. The difference between the two systems is that a refrigeration application is only concerned with the low temperature effect produced at the evaporator, while a heat pump may be concerned with both the cooling effect produced at the evaporator as well as the heating effect produced at the condenser. In these dual-mode GSHP systems, a reversing valve is used to switch between heating and cooling modes by reversing the refrigerant flow direction. The third loop in the system is the ground loop in which water or an antifreeze solution exchanges heat with the refrigerant and the earth.

Technology Description

Geothermal energy is the natural heat that exists within the earth and that can be absorbed by fluids occurring within, or



Abdeen Mustafa Omer, MSc, PhD is an Associate Researcher at Energy Research Institute (ERI). He is PhD from the University of Nottingham. He graduated from University of El Menoufia, Egypt. He has been listed in the book WHO'S WHO in the World 2005, 2006, 2007 and 2010. He published over 300 papers, 100 review articles, 5 books and 100 chapters in books.

introduced into, the crystal rocks. Although, geographically, this energy has local concentrations, its distribution globally is widespread. The amount of heat that is, theoretically, available between the earth's surface and a depth of 5 km is around 140 x 1024 joules. Of this, only a fraction (5 x 1021 joules) can be regarded as having economic prospects within the next five decades, and only about 500 x 1018 joules is likely to be exploited by the year 2020. Three main techniques are used to exploit the heat available: geothermal aquifers, hot dry rocks and ground source heat pumps.

The GSHP applications are one of three categories of geothermal energy resources as defined by ASHRAE. These categories are:

- High-temperature (>150^{O}C) suitable for electric power production,
- Intermediate- and low-temperature (<150^{O}C) suitable for direct-use applications,
- Low temperature GSHP applications (generally (32^{O}C).

The GSHP applications are distinguished from the others by the fact that they operate at relatively low temperatures. However, GSHPs can also be categorised based on the use of heat source/sink, and this study will explore these in details. The conceptual integration of various warm/cold energy sources combined with thermal energy storage system is illustrated as shown in Fig. 3. The shapes and numbers of the internal channels and the optimum configuration will obviously depend on the operating characteristics of each installation.

Electric heating is still one of the most frequent types in residential heating and cooling systems. To improve the energy efficiency of such systems, installation of a heat pump is a popular alternative. It is, however, even more common to replace oil and wood-boilers with heat pumps. For reasons of economy as well as operation, even GSHPs are rarely designed to cover maximum heat demand. A rule of thumb says that a capacity of 50% of the building design load will cover 80-90%

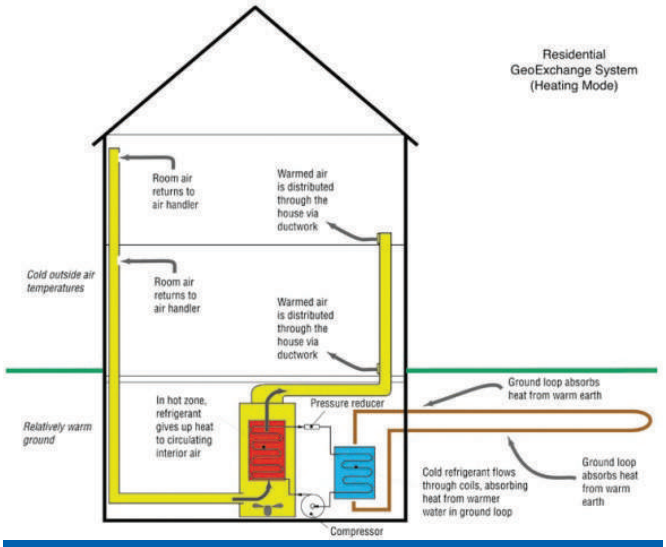


Fig. 1: Residential GeoExchange Systems (Heating Mode)

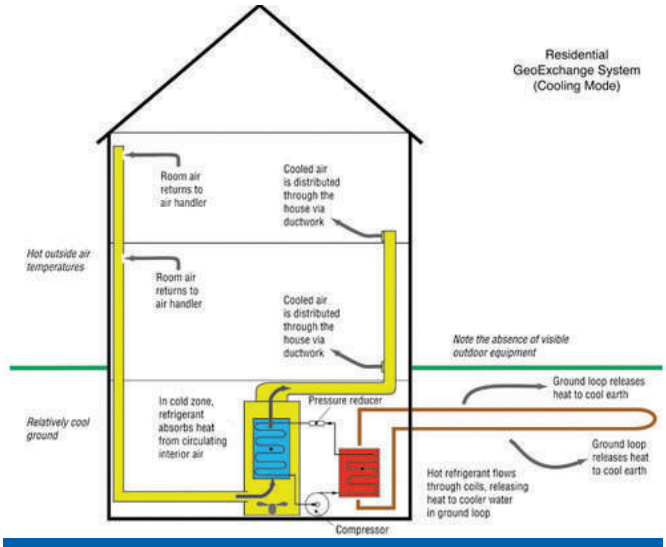


Fig. 2: Residential GeoExchange Systems (Cooling Mode)

of the annual demand for space heating (typical outdoor design temperatures vary between –20 to –30^{O}C).

The term "ground source heat pump" has become an all-inclusive term to describe a heat pump system that uses the earth, ground water, or surface water as a heat source and/or sink. Some of the most common types of ground source ground-loop heat exchangers configurations are classified in Fig. 4.

A main core with several channels will be able to handle heating and cooling simultaneously, provided that the channels to some extent are thermally insulated and can be operated independently as single units, but at the same time function as

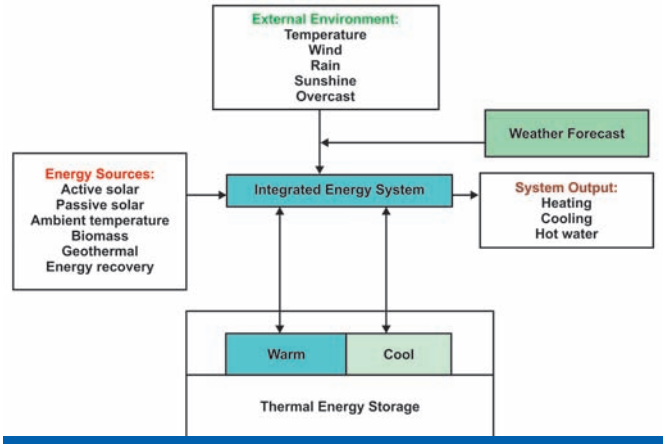


Fig. 3: Conceptual illustration of an integrated energy system with thermal storage

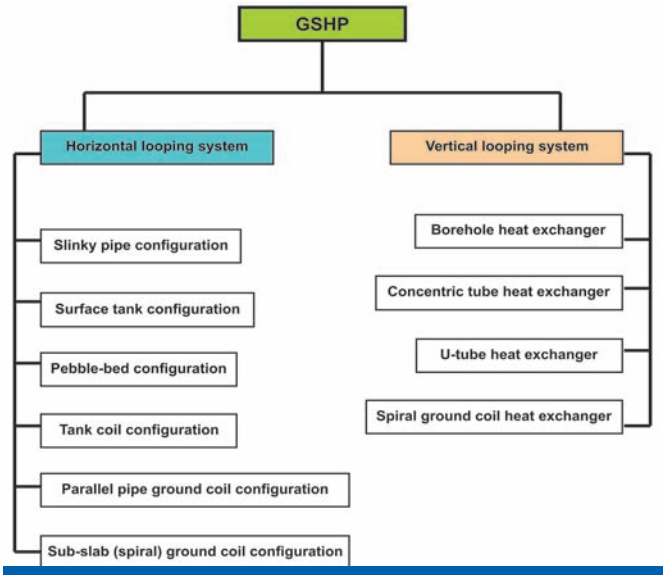


Fig. 4: Flow chart of combined heating & cooling with air-source heat pump and energy recovery from return air in combination with Environ-core thermal storage

integral parts of the entire core. The shapes and numbers of the internal channels and the optimum configuration will obviously depend on the operating characteristics of each installation some possible configurations are shown in Fig. 5. Loading of

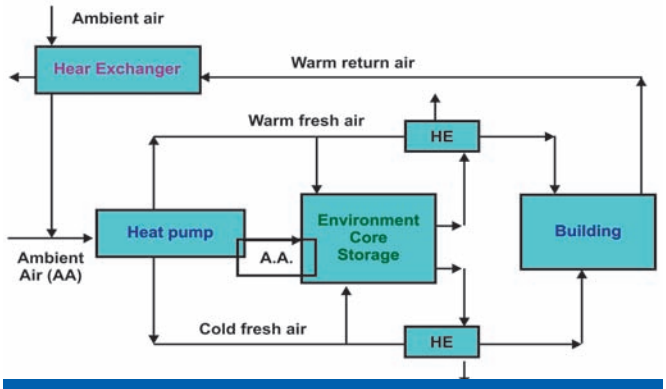


Fig. 5: Flow sheet of combined heating & cooling with air-source heat pump and energy recovery from return air in combination with Environ-core thermal storage

the core is done by diverting warm and cold air from the heat pump through the core during periods with excess capacity compared to the current need of the building. The cool section of the core can also be loaded directly with air during the night, especially in spring and fall when nights are cold and days may be warm.

Model TRNSYS Description

The following are summarised.

Controls

The TRNSYS simulation programme has been used to model one of the hottest technologies in the HVAC market today. GSHPs use the earth as a thermal reservoir to provide conditioned air for heating and cooling of buildings. The heat pump components are controlled by a three-stage room thermostat model in TRNSYS (Fig. 6). The thermostat employs night setback & a deadband and operates as described in Fig. 6. The heat pump components are controlled by a three-stage room thermostat model in TRNSYS. The thermostat employs night setback and a deadband and operates in the heating and cooling modes.

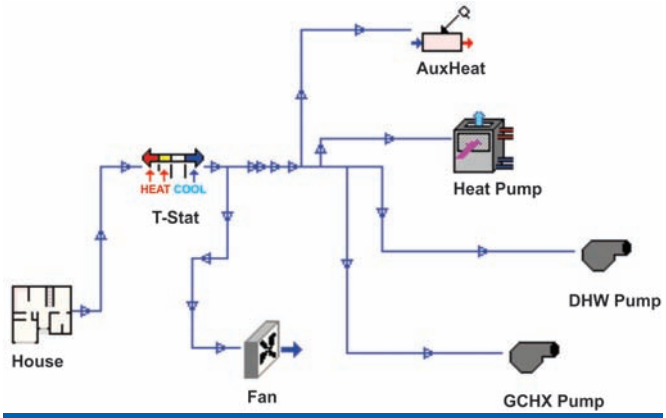


Fig. 6: Modelling of closed loop GSHP

Heating Mode

If the room temperature falls below the user-specified set point for heating minus the thermostat deadband, the thermostat will call for heating by the heat pump and provide enable signals to the ground loop pump, the fan, and the domestic hot water loop pump. If the room temperature continues to fall further and reaches the auxiliary heating set point minus the deadband, the thermostat will call for auxiliary heating by the electric resistance heater. The fan, ground loop pump, and domestic hot water loop pump will remain on. The auxiliary heater will remain on until room temperature rises above the auxiliary heater set point temperature at which point the auxiliary heater will shut off; leaving the ground loop pump, the fan, and the hot water loop pump on. The heat pump, ground loop pump, hot water loop pump, and fan will remain on until the room temperature rises above the heating set point temperature.

Cooling Mode

If the room temperature rises above the user-specified set point for cooling plus the thermostat deadband, the thermostat will call for cooling by the heat pump and provide enable

signals to the ground loop pump, the fan, and the domestic hot water loop pump. The heat pump, ground loop pump, hot water loop pump, and fan will remain on until the room temperature falls below the cooling set point temperature.

When the thermostat calls for cooling, the fan will move air from the building to the heat pump where it is cooled as it crosses the cooling coil. The cool air is then dumped back into the building until the thermostat is satisfied. The heat removed from the air and transferred to the refrigerant is then rejected to a cooling fluid stream (typically water in southern climates). This hot fluid is then pumped to ground heat exchangers that are buried in the earth where the heat is transferred to the soil.

In heating mode, this process is reversed. When the thermostat calls for heating, the fan will move air from the building to the heat pump where it is heated as it crosses the heating coil. This warm air is then dumped back into the building until the thermostat is satisfied. If the thermostat calls for auxiliary heating, an electric resistance heater located at the air outlet from the heat pump will heat the air up even further. The heat absorbed by the air from the refrigerant is removed from the fluid stream. This cool fluid is then sent to the ground heat exchangers to absorb energy from the soil so that the process may be repeated.

The heat pump for this simulation has an option for heating hot water by the use of a desuper-heater. While operating in either heating or cooling mode, cool water is removed from the bottom of the hot water storage tank and passed across the desuperheater of the heat pump. Energy is transferred from the refrigerant to the water by the desuperheating of the refrigerant. The hot water is then pumped back to the top of the hot water storage tank for later use.

Loads

The loads that the ground source heat pump system must meet are dependent on several important factors: the weather, occupancy schedule, lighting schedule, infiltration, internal gains, and ventilation effects. Unlike most of the major simulation programmes on the market today, TRNSYS does not decouple the loads from the HVAC system. The loads and the system response are solved simultaneously providing a much more accurate solution.

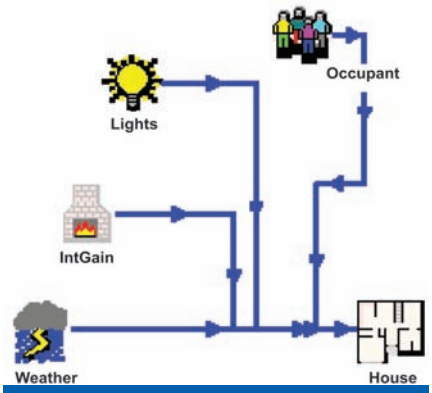


Fig. 7: Factors affecting GSHP load

Building Model

In TRNSYS there are several different building models that could have been chosen to perform the load calculations (detailed multi-zone building, detailed single-zone building model, degree-day building model, etc.). In this simulation, the building is modelled with a new lumped capacitance-building model written by the Thermal Energy System Specialists of Madison, WI. This new subroutine represents a simpler approach to building simulation than the standard TRNSYS models, but makes for extremely quick simulation times.

Weather

The TRNSYS programme has two unique methods of providing weather data to simulations. Weather data may be read from a data file (Typical Meteorological Year weather files are available for TRNSYS), or weather data may be generated based on monthly averages of solar radiation, ambient temperature, humidity ratio, and wind speed. This simulation utilises the TRNSYS weather generator component. A file of monthly averages for 330 U.S.A and Canadian cities is included with the programme. In this simulation, the weather generator component allows the user to quickly choose from any of the 330 sites with a click of the mouse. The building model requires the ambient temperature (for skin losses and sensible infiltration gains/losses) and the ambient humidity ratio (for latent infiltration gains). The COP is usually 3 or higher. The best GSHPs are more efficient than high-efficiency gas combustion, even when the source efficiency of the electricity is taken into account.

Internal Loads

The building model allows the user to specify the internal gains to the space. In this simulation, the internal gains will be varied throughout the day based on a pre-defined schedule. This schedule is input to the programme by the use of the TRNSYS forcing function component.

Lighting Loads

The building model allows the user to specify the lighting gains to the space. In this simulation, the lighting gains will be varied throughout the day based on a pre-defined schedule. This schedule is input to the programme by the use of the TRNSYS forcing function component.

Occupancy Gains

The building model allows the user to specify the sensible and latent gains to the space. In this simulation, the occupancy will be varied throughout the day based on a pre-defined schedule. This schedule is input to the programme by the use of the TRNSYS forcing function component.

Infiltration

The infiltration gains/losses are calculated by the simple ASHRAE approach to infiltration (K1, K2, K3 methods). These loads are then input to the building model. When heating or cooling is required of the heat pump, the ground loop pump will move fluid from the ground heat exchangers to the heat pump (Fig. 8). The heat pumps will then add/remove heat from the fluid and return the fluid to the ground loop where this heat must be rejected to/ absorbed from the earth.

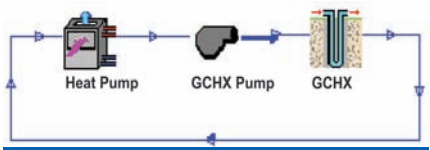


Fig. 8: GSHP system operations

Ground Loop

The ground loop operates in the following manner. When heating or cooling is required of the heat pump, the

ground loop pump will move fluid from the ground heat exchangers to the heat pump. The heat pump will then add/remove heat from the fluid and return the fluid to the ground loop where this heat must be rejected to/absorbed from the earth.

The key components in any ground source heat pump application are the ground heat exchangers. In this simulation, two U-tube ground heat exchangers are used to reject/absorb heat to/from the ground. U-tube ground heat exchangers are relatively simple devices. The heat exchanger consists of a long piece of pipe formed into a "U" shape. This U-tube is then inserted into a deep hole drilled into the earth called a borehole. After the U-tube has been placed in the earth, the borehole is backfilled with soil or a thermal-enhanced grout. The two ground heat exchangers are hooked up in parallel and are typically buried about 15 feet apart. The ground heat exchanger design is critical in these systems. If the ground heat exchangers are too short, the temperature of the fluid returning to the heat pump is too hot (cooling) or too cold (heating); causing performance degradation and possible equipment failure.

In this simulation, the thermal and hydraulic effects of the horizontal pipes leading to and from the ground heat exchangers are ignored since they typically account for only a small fraction of the overall heat transfer.

The ground heat exchangers are modelled with a very detailed model written at the University of Lund, Sweden. This model accounts for the thermal properties of the fluid, pipes, backfill, and soil and is considered the finest ground heat exchanger model in the world today. This model has been incorporated into TRNSYS to take advantage of the many TRNSYS benefits derived from modular simulation.

Air system

The air system in this simulation is relatively simple. When heating or cooling is required, a thermostat control signal will enable the fan, which draws conditioned air from the building (Fig. 9). The room air then passes over the heating/cooling coil of the heat pump;

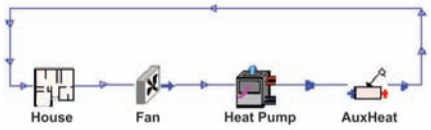


Fig. 9: Air pump systems

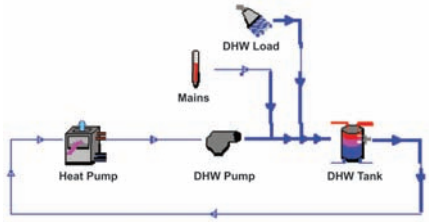


Fig. 10: Hot water system

which then heats or cools the air (taking into account both the sensible and latent considerations). The GSHPs are environmentally attractive because they deliver so much heat or cooling energy per unit of electricity consumed.

The heating/cooling capacity of the heat pump is a function of the airflow rate, the air temperature, the water flow rate, and the water temperature. The capacity will be read from a look-up table and used to determine the exiting air conditions from the heat pump. The air leaving the heat pump passes over the auxiliary heating coil, which is controlled by the thermostat based on the room temperature, and is returned to the building. Duct losses (both pressure and temperature) are ignored in this simulation (although they easily could be calculated).

Hot Water

The heat pump is equipped with a desuperheater, which is used to heat hot water for use in the building (Fig. 10). When the heat pump is operating (in either heating or cooling mode), a pump draws cool water from the bottom of the storage tank, passes the water across the desuperheater where it is heated, and returns the hot water to the top of the storage tank.

To calculate the effects of the desuperheater on hot water tank energy use, a water draw profile, and make-up water temperature profile are required. These profiles are input to the programme through the use of the TRNSYS forcing function component. The thermal and hydraulic losses due to the pipes leading to/from the storage tank are ignored in this simulation.

Output

Using a special TRNSYS component for simulation, the following variables will be plotted as the simulation progresses. Fig. 11 presents the output of the system.

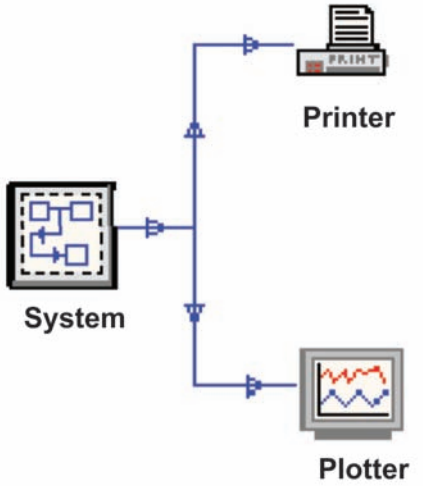


Fig. 11: Diagram of output

Once the time period and variables have been selected, a plot window is displayed in the TRNSYS programme Fig. 12.

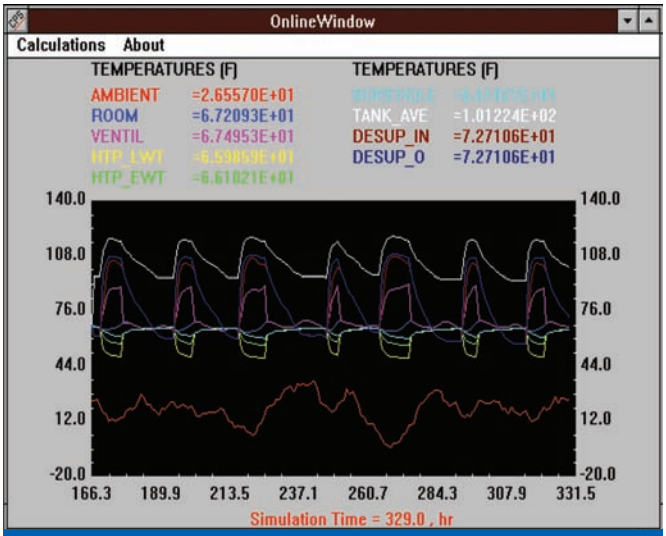


Fig. 12: Shows the output of the system

Where:	
Ambient	The ambient temperature
Room	The room temperature
Ventil	The room ventilation temperature
HTP_LWT	The temperatures of the water leaving the heat pump
HTP_EWT	The temperatures of the water entering the heat pump
Borehole	The borehole temperature (backfill)
Tank_Ave	The average hot water tank temperature
Desup_In	The temperature of the hot water stream entering the heat pump desuperheater
Desup_O	The temperature of the hot water stream entering the heat pump desuperheater

Once the time period & variables have been selected, a plot window is displayed in the TRNSED programme. The features of this plot window may be modified by double-clicking on them with the mouse (symbols, grid lines, scales, titles, legends, etc.). A sample plot window from the simulation is shown in Fig. 13. The following items were plotted versus time:

MINLWT	The minimum temperature of the water leaving the heat pump during the week.
MAXLWT	The maximum temperature of the water leaving the heat pump during the week.
MINEWT	The minimum temperature of the water entering the heat pump during the week.
MAXEWT	The maximum temperature of the water entering the heat pump during the week.

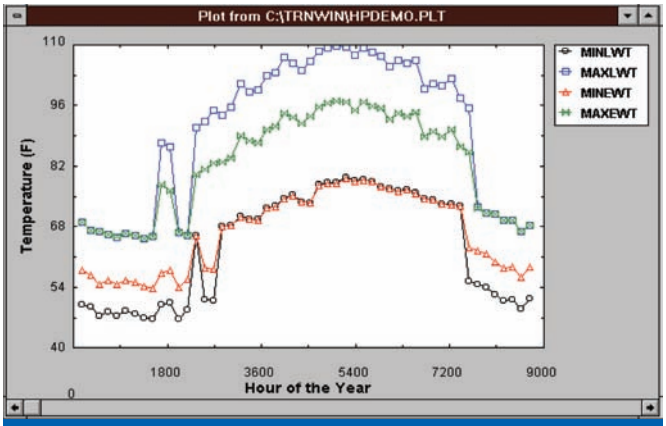
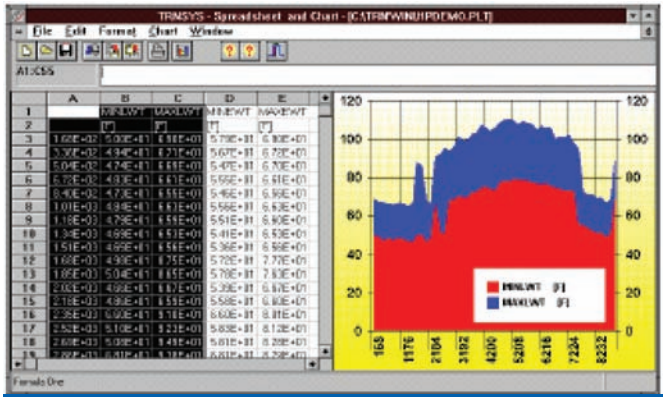


Fig. 13: Water temperatures entering and leaving the heat pump



he minimum and maximum temperature of the water entering the heat pump during the week

The output file may also be loaded into the TRNSYS Spreadsheet and Plotting programme for further manipulation. The spreadsheet is Excel compatible and features a 3-D (and 2-D) plotting package. The user simply highlights the area of the spreadsheet to be plotted, and selects the type of plot. A sample plot from the programme is shown in Fig. 14. The newly created plot may be manipulated in many ways and produces fantastic publication-quality graphics that can be pasted into most Windows applications. The spreadsheet programme is not included with the demo.

Some Systems can also be used for Cooling in the Summer

Having given up its heat, the refrigerant passes through the expansion device, where its temperature and pressure are dropped further before it returns to the first heat exchanger or to the ground in a DX (direct expansion) system, to begin the cycle again (Fig. 15).

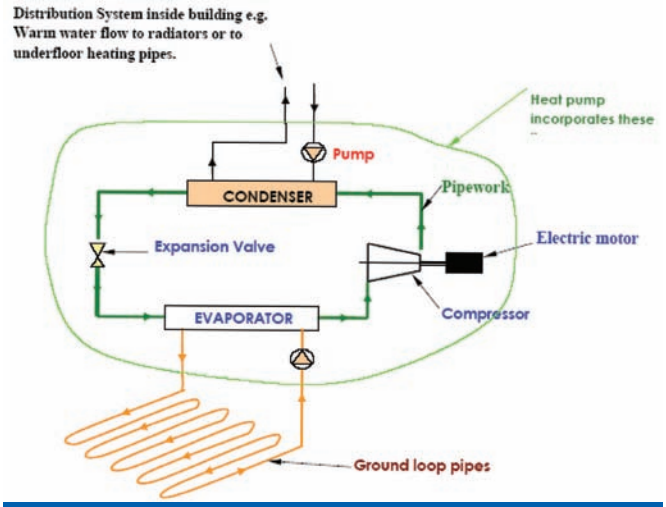


Fig. 15: Ground loop heat pump

In winter water sources can be at a higher temperature than outside air, these include; lakes, deep ponds and rivers. Other sources of low grade energy are sub-soil, and waste products from industry such as effluent and power station waste water. The diagram in Fig. 16 shows typical COP's for a heat pump. Heat pumps function by moving (or pumping) heat from one place to another. Like a standard air-conditioner, a heat pump takes heat from inside a building and dumps it outside. The difference is that a heat pump can be reversed to take heat from a heat source outside and pump it inside. Heat pumps use electricity to operate pumps that alternately evaporate and condense a refrigerant fluid to move that heat. In the heating mode, heat pumps are far more "efficient" at converting electricity into usable heat because the electricity is used to move heat, not to generate it.

The most common types of the heat pump is air-source heat pump (ASHP), which uses outside air as the heat source during the heating season and the heat sink during the air-conditioning season. Ground-source and water-source heat pumps work the same way, except that the heat source/sink is the ground, groundwater, or a body of surface water, such as a

lake. For simplicity, water-source heat pumps are often lumped with ground-source heat pumps, as in this case (Fig. 17).

The efficiency or coefficient of performance (COP) of the GSHPs is significantly higher than that of air-source heat pumps because the heat source is warmer during the heating season and the heat sink is cooler during the cooling season. GSHPs are also known as geothermal heat pumps. The GSHPs are environmentally attractive because they deliver so much heat or cooling energy per unit of electricity consumed. The COP is usually 3 or higher. The best GSHPs are more efficient than high-efficiency gas combustion, even when the source efficiency of the electricity is taken into account.

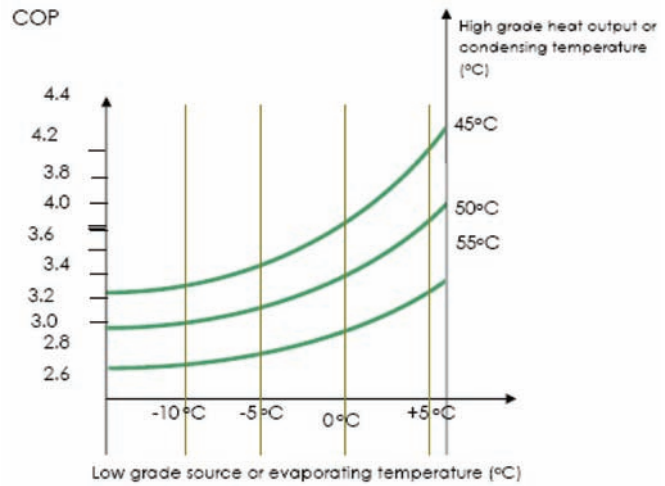


Fig. 16: The diagram shows typical COP's for a heat pump

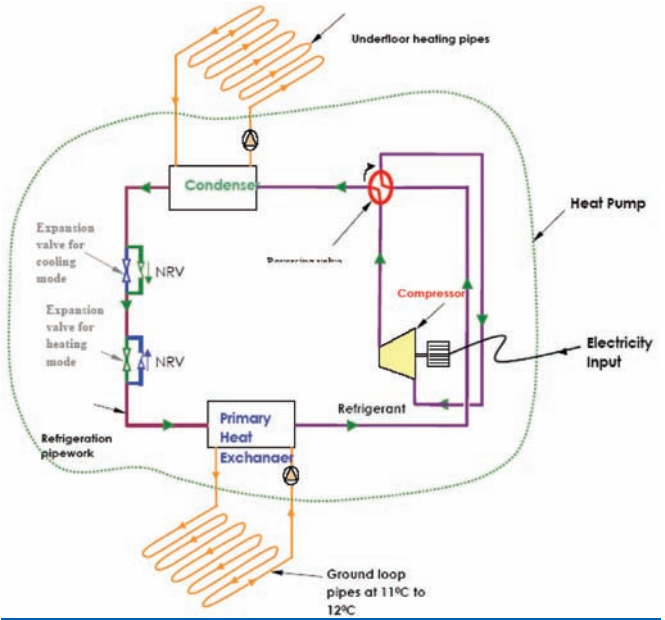


Fig. 17: Ground loop pipes at 11-12°C

Typical Heat Pump Performance

In summary, the coefficient of performance (COP) is improved if the temperature of the cold side (heat source) is raised. For this reason heat pumps can be seen as devices able to convert low grade thermal energy to useful heat. It can be seen that the COP is increased with higher evaporating temperatures, this means that the higher the low grade energy source temperature the higher the COP.

In winter water sources can be at a higher temperature than outside air, these include; lakes, deep ponds and rivers. Other sources of low grade energy are sub-soil, and waste products from industry such as effluent and power station waste water. The indoor heat exchanger becomes a condenser giving out heat whereas the outdoor heat exchanger is the evaporator and takes in heat energy from a low grade source (Fig. 18).

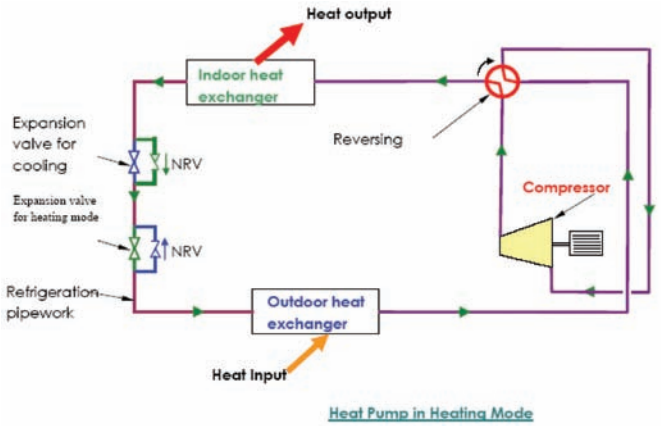


Fig. 18: Heat pump at heating mode

The diagram in Fig. 19 shows the same plant with the reversing valve set for the cooling mode. The refrigerant travels around the system in the opposite direction and arrives at the Outdoor heat exchanger first after the compressor.

This is effectively the condenser where heat is rejected to atmosphere. The refrigerant passes through a non-return valve and expansion valve where it then passes through the indoor heat exchanger, which is the evaporator or cooling coil.

The GSHPs are generally most appropriate for residential and small commercial buildings, such as small-town post offices. In residential and small (skin-dominated) commercial buildings, GSHPs make the most sense in mixed climates with significant heating and cooling loads because the high-cost heat pump replaces both the heating and air-conditioning system. Because GSHPs are expensive to install in residential and small commercial buildings, it sometimes makes better economic sense to invest in energy efficiency measures that significantly reduce heating and cooling loads, and then install less expensive heating and cooling equipment. The savings in equipment may be able to pay for most of the envelope improvements. If a GSHP is to be used, planning the site work and project scheduling needed so carefully that the ground loop can be installed with minimum site disturbance or in an area that will be covered by a parking lot or driveway.

Direct-exchange GSHPs use copper ground-loop coils that are charged with refrigerant. This ground loop thus serves as one of the two heat exchangers in the heat pump. The overall efficiency is higher because one of the two separate heat exchangers is eliminated, but the risk of releasing the ozone-depleting refrigerant into the environment is greater. Direct-exchange systems have a small market share.

The heat pump is used to produce heat from a low-grade energy source such as outside air, a lake, pond or seawater. The refrigeration cycle is utilised so that the heat rejected at the condenser is used to heat a building as shown in Fig. 20. This is the opposite function of the condenser when the 'fridge cycle' is used for air conditioning, in which case the heat rejected is lost to the atmosphere.

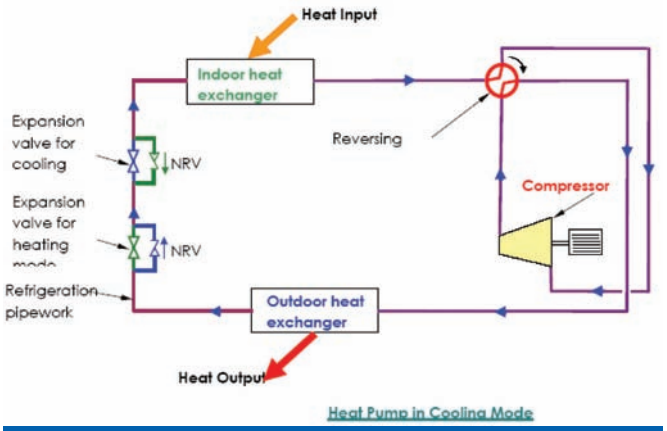


Fig. 19: Heat pump at cooling mode

The compressed gas from the compressor is passed to the condenser where heat is removed for use, and in the evaporator the refrigerant absorbs heat at a relatively low temperature from the heat source. A typical example would be an air to air heat pump, which extracts heat from outside air even at very low winter temperatures by using the vapour compression refrigeration cycle in reverse mode. This can produce warm air at the condenser to heat a building. Heat pumps work best when a building needs to be heated during winter and cooled in summer.

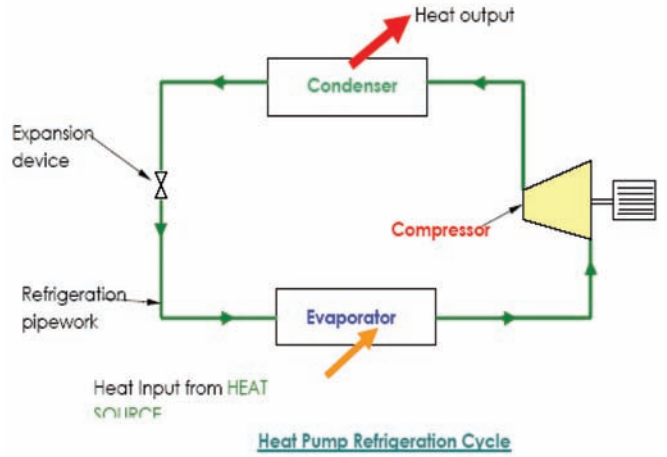


Fig. 20: Heat pump refrigeration cycle

One of the disadvantages of a heat pump is the amount of electrical energy used to drive the compressor. This can be overcome in large installations by running the compressor from a gas driven engine. Another difficulty is noise and several heat pumps can be linked to one remote compressor to reduce local noise. This has the added advantage that compressor maintenance is centralised.

The Heat Pump

The GSHPs are special versions of conventional water source heat pumps designed to operate over an extended range of entering water temperatures. Typical entering water temperatures can range from -5^{O}C to +12^{O}C for heat pumps delivering heat with maximum output temperatures, sometimes as high as 50-55^{O}C. The lower the heating output temperature and the higher the source input temperature the more efficiently the heat pump will operate.

The performance of heat pumps can vary widely so it is important to select an efficient unit. The heat pump output is a function of the rated efficiency of the unit and this should be quoted in manufacturer's data. This is the result of performance testing under standard test conditions such as those specified in BS EN 255-2:1997 [6] air conditioners, liquid chilling packages and heat pumps with electrically driven compressors- heating mode. The performance data should provide the coefficient of performance (COP), measured as the heat output (kWth) divided by the electrical input (kWel), at standard test conditions for brine/water heat pumps (i.e., brine input temperature of 0^{O}C and water output temperature of 50^{O}C, etc.). Fig. 21 shows coefficients of performance (COP) measured under test conditions for a typical GSHP. The efficiency for a specific installation will also be dependent on the power required by the ground loop circulating pump and this should be kept as low as possible.

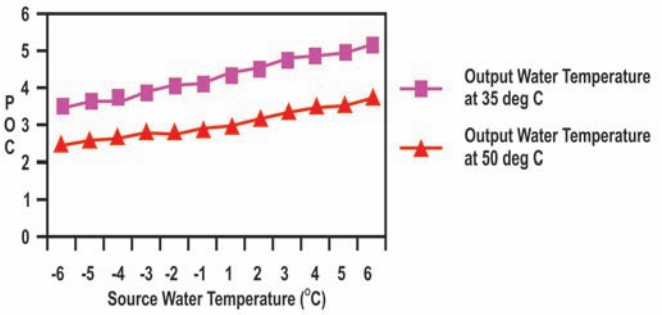


Fig. 21: Coefficients of performance of typical small domestic GSHPs

Space Heating

Table 1 shows the supply temperatures required for a range of domestic heating distribution systems. The GSHP systems may not be suitable for direct replacement of conventional water-based central heating systems because of the high distribution temperatures unless extensive measures are taken to improve the thermal insulation of the building. A wet radiator system usually operates at 60^{O}C to 80^{O}C & a drop in circulating temperature by 20^{O}C would require an increase in emitter surface of 30% to 40% to maintain the same heat output. For an air system reducing the delivery temperature to 35^{O}C would require increasing the air change rate by up to three times to maintain the same output. For new housing where high insulation levels result in low heating demand, low temperature air distribution systems, low temperature water-based systems or underfloor heating are all possible options. The most efficient type of space heating to use with a GSHP system is underfloor heating. Ideally the system should be designed to give floor

surface temperatures no higher than 26^{O}C & should be sized using a water temp. difference of about 5^{O}C (Tables 2 and 3).

Distribution System	Delivery temperature ^{O}C
Underfloor heating	30-45
Low temperature radiators	45-55
Conventional radiators	60-90
Air	30-50

Table 1: Typical delivery temperatures for various heating distribution systems

Product Type	EER[b]	COP[c]	EER[b]	COP[c]
Closed Loop[a]	14.1 or more	3.3 or more	25.8	4.9
Open Loop[b]	16.2 or more	3.6 or more	31.1	5.5

Table 2: Coefficient of Performances (COP)

a) The best available Coefficient of Performance and best available Energy Efficiency Ratio for the open-loop system apply to different models.
b) EER is the cooling capacity (in Btu/hour) of the unit divided by its electrical input (in Watts) at standard (ARI/ISO) conditions of 77^{O}F entering water for closed-loop models & 59^{O}F entering water for open-loop systems.
c) COP is the heating capacity (in Btu) of the unit divided by its electrical input (also in Btu) at standard (ARI/ISO) conditions of 32^{O}F entering water for closed-loop models and 50^{O}F entering water for open-loop equipment.
d) Open-loop heat pumps, as opposed to closed-loop models, utilise "once-through" water from a well, lake or stream.

Cost-Effectiveness for Example, 25,000 ft² Office Building

Performance	Air-Source Heat Pump	Gas Furnace Air-source AC	Recommended Level GSHP	Best Available GSHP
Heating/ Cooling Efficiency	11.0 EER/ 2.9 COPa	11.0 EER/ 90% AFUE	14.1 EER/ 3.3 COPa	25.8 EER/ 4.9 COPa
Annual Cooling Energy Use	37,700 kWh	37,700 kWh	30,700 kWh	20,400 kWh
Annual Heating Energy Use	29,800 kWh	1,970 therms	12,600 kWh	10,900 kWh
Annual Energy Cost	$4,050	$3,050	$2,600	$1,900
Lifetime Energy Costb	$43,000	$32,000	$27,000	$20,000
Lifetime Energy Cost Savings	—	$11,000	$16,000	$23,000

Table 3: Cost effectiveness

a) The modelled 2.9 coefficient of performance (COP) heating efficiency of the air-source heat pump is halfway between the cold weather (17^{O}F) & standard, mild weather (47^{O}F) rating conditions of a new high-efficiency (FEMP-recommended & ENERGY STAR model. Similarly, the modelled cooling efficiencies of the air-source heat pump, gas furnace, and air-source air conditioner all represent models that just meet the FEMP- recommended and ENERGY STAR qualifying levels.
b) Lifetime energy cost is the sum of the discounted value of the annual energy costs based on average usage and assumed equipment life of 15 years. The GSHPs generally last longer than this, but 15 years is used since this is the expected life of the air-source equipment. The assumed electricity and gas prices are $0.06/kWh and $0.40/therm; the average energy prices. Future energy price trends and a discount rate is 3.3%.

Because of the higher output temperature, the seasonal performance of a low temperature radiator system will not be as high as that for an underfloor design (Fig. 22). Fan convectors can be used but flow temperatures of around 50^{O}C may be necessary to ensure high enough air temperatures, which will also reduce the system efficiency. The thermal capacity of the distribution system is important. If it is too low the heat pump may suffer from artificially long off periods at times of light load. This effect is partly due to the presence of a restart delay (designed to reduce wear on the compressor by preventing rapid on/off cycling) in the heat pump.

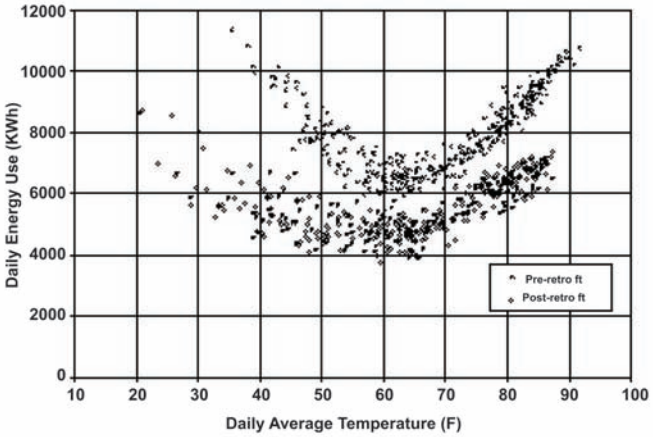


Fig. 22: Daily energy uses v daily average temperature

To avoid it, sufficient non-disconnectable thermal capacity to compensate for the loss of output during the delay restart period needs to be provided. The heat pump manufacturer's guidance should be followed but it may be necessary to install a 'buffer' tank in order to optimise the running time of the heat pump. The required capacity will depend on the system but is likely to be between 60 and 150 litres. Night setback is also unlikely to be appropriate. The main function of the timeclock is likely to be to try and maximise the use of any cheaper electricity tariffs (Fig. 23).

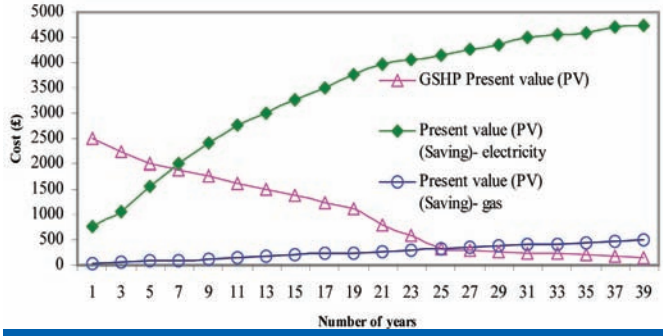


Fig. 23: Comparison of present values of different energy sources

Vertical energy systems (closed loop) utilise the natural thermal properties of the earth in a similar manner to the ground water energy systems (Fig. 24). However, instead of pumping water out of a well then back into the ground, simply circulate water or an antifreeze solution through a closed loop network of plastic pipe that is inserted into vertical wells. Horizontal energy systems (closed loop) also utilise the earth's

Fig. 24: Vertical energy systems

Fig. 25: Horizontal energy systems

Fig. 26: Pond / lake energy systems

plentiful & renewable thermal characteristics (Fig. 25). The earth loop exchanges heat with the soil. Horizontal loops are most common.

Pond or lake energy systems (closed loop) may be the most economical system to install and has many advantages for producing energy savings (Fig. 26).

Conclusion

Heat pump technology can be used for heating only, or for cooling only, or be 'reversible' and used for heating & cooling depending on the demand. Reversible heat pumps generally have lower COPs than heating only heat pumps. They will, therefore, result in higher running costs and emissions and are not recommended as an energy-efficient heating option.

The GSHP system can provide 91.7% of the total heating requirement of the building and 55.3% of the domestic water-heating requirement, although only sized to meet half the design-heating load. The heat pump can operate reliably and its performance appears to be at least as good as its specification. The system has a measured annual performance factor of 3.16. The occupants will be pleased with the comfort levels achieved and find the system quiet and unobtrusive. The heat pump is mounted in a cupboard under the stairs and does not reduce the useful space in the house, and there are no visible signs of the installation externally (no flue, vents, etc.). The GSHP system is responsible for lower CO_2 emissions than alternative heating systems (the emission figures for an all-electric system and oil- or gas-fired boilers are given in Table 5). For example, compared with a gas-condensing boiler, the heat pump system resulted in 15% lower CO_2 emissions (assuming a CO_2 emission factor for electricity of 0.46 kg/kWh). When compared with new oil fired boiler system or all-electric systems, the emissions of CO_2 are cut by over 40% and nearly 60% respectively.

Annual fuel costs, based on the fuel prices given in Standard Assessment Procedure (SAP, 1998), are about 10% higher than those for a gas condensing boiler and about 20% higher than for a new regular oil boiler, but servicing costs are likely to be lower. Running costs are substantially cheaper than for an all-electric heating system. At present, suitable products are not readily available in the UK, so the heat pump had to be imported. This had drawbacks, e.g., limited documentation in English and possible difficulty in obtaining spare parts.The controller supplied with heat pump was not designed for use with an Economy 7 type tariff structure. There is however potential to improve operation of the system by scheduling more of the space and water heating duty during the reduced tariff period. The performance of the heat pump system could also be improved by eliminating unnecessary running of the integral distribution pump. It is estimated that reducing the running time of this pump, which currently runs continuously, would increase overall performance factor to 3.43. This would improve both the economics & the environmental performance of the system. More generally, there is still potential for improvement in the performance of heat pumps, & seasonal efficiencies for ground source heat pumps of 4.0 are being achieved. It is also likely the unit costs will fall as production volumes increase. By comparison, there is little scope to further improve the efficiency of gas- or oil-fired boilers.

Underground thermal energy storage is a new idea. Some underground thermal energy storage (UTES) systems have been already constructed worldwide. Sometimes the users are not aware, that they have used an UTES system. Most of the ground heating systems use heat accumulated in the ground medium in a natural way and they are typically ground coupled heat pump systems. Different types of horizontal and vertical ground heat exchangers are being applied. Due to a lack of tradition and sometimes knowledge of heat pumps and ground systems, some mistakes in planning, designing and construction have been made. Therefore there is a great need to develop good demonstration projects to show advantages of UTES and its role in energy conservation.

The European experience with GSHP systems so far is excellent. It is expected that the market will further expand, in the leading countries like Sweden and Switzerland as well as in other countries to follow. The growth can be exponential as the Swiss example. An important factor, related to the further development of electric heat pump systems in general and the GSHPs in particular, is the current process of deregulation in Europe. The energy sector and especially electric utility companies, are currently under deregulation and privatisation. This affects not only producers but also customers. The deregulation process may affect the heat pump market in two ways:

- Heat pump economy might be influenced by changes in the energy price structure,
- The heat pump market might be stimulated or hindered, depending on changing utility market strategies.

So far, in the regulated market, some utilities have clearly supported heat pumps, in line with governmental energy-efficiency programmes (e.g., by offering grants or special electricity tariffs). However, in a deregulated energy market, the market strategies of utilities will change. Only when the market matures and energy prices drop to a stable level will utilities offer incentives such as products/bonuses or energy efficiency services. Nevertheless, the ecological incentives like avoiding GHGs emissions will further support GSHP development. The CO_2 tax in sight is a further (financial) incentive. Of course, there will be considerable differences in this respect from country to country. ■

Heat Exchangers
Classification, Design and Analysis

Heat exchangers are devices that facilitate heat transfer between two or more fluids at different temperatures. Heat exchangers are extensively used in steam power plants, chemical industry, building heating and air-conditioning, refrigerators, car radiators etc.

In common types (shell and tube heat exchangers) heat transfer is primarily by conduction and convection from a hot to a cold fluid, which are separated by a metal wall. In the most efficient heat exchangers, the surface area of the wall between the fluids is maximized while simultaneously minimizing the fluid flow resistance. Fins or corrugations are sometimes used with the wall in order to increase the surface area and to induce turbulence so that heat transfer rate is enhanced.

Classification

Heat exchangers are designed in many sizes, types, configurations and flow arrangements depending upon the requirement. They can be classified from different points of views as-

- **According to heat transfer processes:** Based on the mode of heat transfer process, heat exchanger can be classified as:

Direct contact type: This type of heat exchanger is used for the two immiscible fluids at different temperatures and they come in direct contact. Normally, one fluid is sprayed through the other. Examples are cooling towers, jet condensers, open feed water heaters etc. Figure 1 shows the heat exchange process in a cooling tower.

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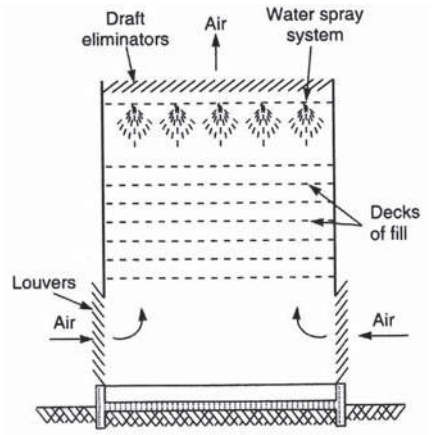


Fig. 1: Direct contact type heat exchanger

Recuperators: The cold and the hot fluids flow simultaneously through the device and heat is transfer through the separating wall between them. These are mostly used in all fields of engineering.

Regenerators or storage type heat exchanger: The hot and the cold fluids flow alternatively over the same surface. The surface stores internal energy when hot fluid flows over it and the stored energy is transferred to the cold fluid when it flows over it in the next interval of time. A matrix is there in the flow path to store heat energy (Fig. 2a). Regenerator heat exchangers are made up of materials with high volumetric heat capacity and low thermal conductivity in the longitudinal (flow) direction. In some cases, a rotating disc type matrix is used (Fig. 2b) for getting continuous flow of both the hot and cold fluids.

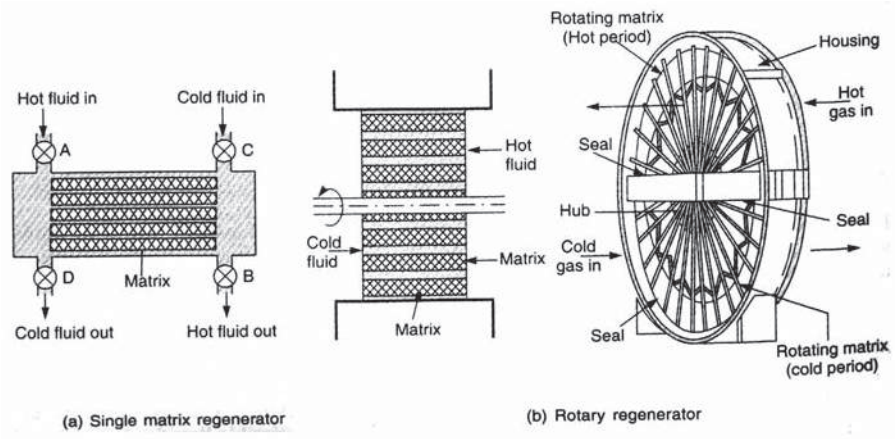


Fig. 2: Storage type heat exchanger (Regenerators)

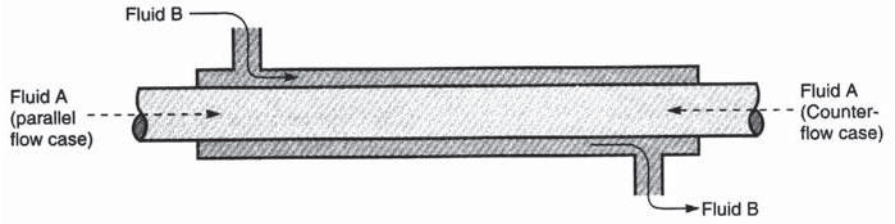


Fig. 3: Tubular heat exchanger

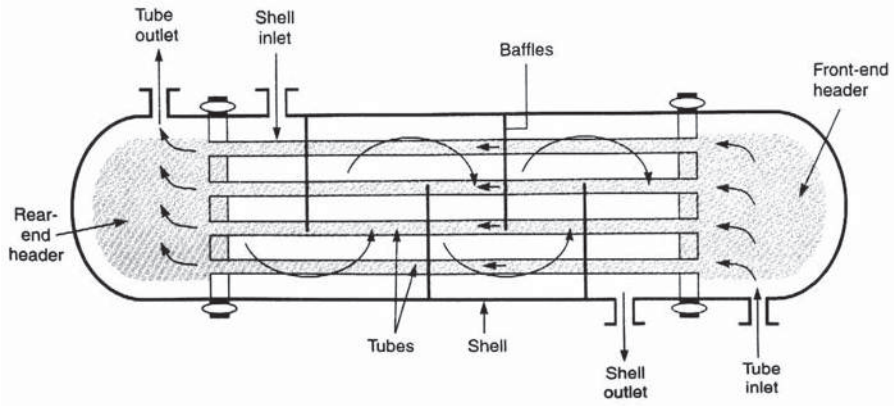
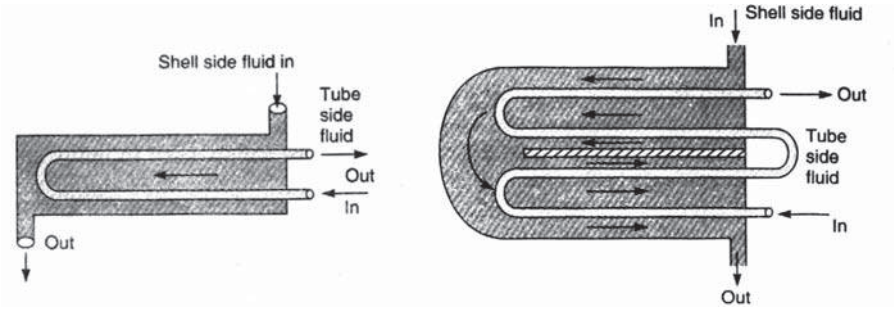


Fig. 4: Shell and tube type heat exchanger (one shell and one tube pass)



(a) One shell pass and two tube pass *(b) Two shell pass and four tube pass*

Fig. 5: Multipass flow arrangement in shell and tube type heat exchanger

- **According to constructional features**

Tubular heat exchanger: Figure 3 shows a tubular heat exchanger. This type of heat exchanger is also called tube in tube or concentric tube or double pipe heat exchanger.

Finned tube type: Fins are extended surfaces used on one side of the heat exchanger for the enhancement of heat transfer rate. Fins are always added on gas side. Finned tubes are used in gas turbines, automobiles, aeroplanes, refrigeration, electronics, cryogenics and air conditioning etc.

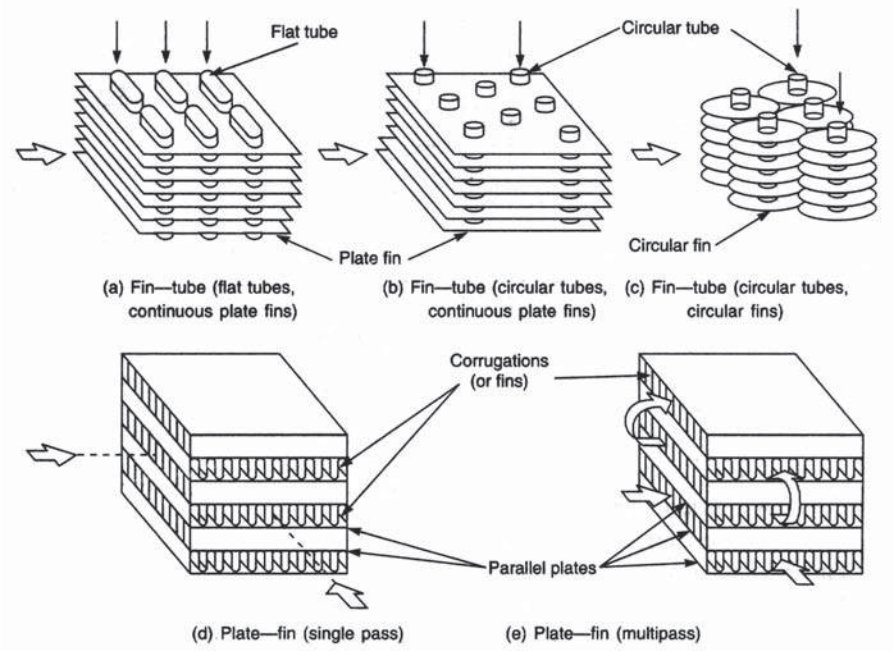


Fig. 6: Arrangement for different types of compact heat exchangers

Compact heat exchanger: In this type of heat exchanger, the heat transfer surface area per unit volume (called area density) is very large. Normally, a heat exchanger having area density more than 700 m^2/m^3 is called compact heat exchanger. This value for automotive radiators is approximately 1100 m^2/m^3. These heat exchangers are used for gas to liquid and gas to gas heat exchange. Different types of compact heat exchangers have been shown in figures 6(a)-(e). Out of these, the first three heat exchangers, namely, fin-tube (flat tubes, continuous plate fins), fin-tube (circular tubes, continuous plate fins) and fin-tube (circular tubes, circular fins) are suitable for use in gas to liquid heat exchangers, where maximum area required is on the gas side. For gas to gas heat exchange, the last two heat exchangers (namely, plate-fin, single pass and plate-fin, multi pass) are most suitable where high area densities are required on both fluids sides.

- **According to flow arrangement:** The heat exchangers may further be classified depending upon the flow directions of the two fluids (hot and cold). They are:

Parallel flow heat exchanger: Both the fluids enter the heat exchanger through the same end and leave at the other end, i.e. they flow in the same direction inside the heat exchanger (Fig. 7a).

Counter flow heat exchanger: The hot and the cold fluids enter through the opposite ends of the heat exchanger and leave also at the opposite ends. They

Shell and tube heat exchanger: It consists of a shell and a large number of parallel tubes housing in it. The baffles are commonly used on the shell to create turbulence and to increase the residence time. This will enhance the heat transfer. A most general type shell and tube heat exchanger is shown in Fig. 4. The shell and tube type heat exchanger is further classified according to the number of shell and

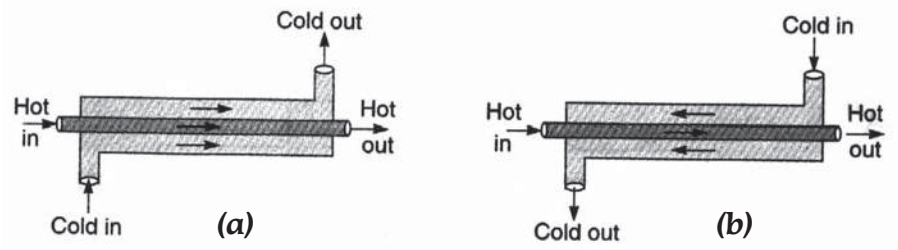


Fig. 7: Flow arrangement: (a) parallel flow, (b) counter flow

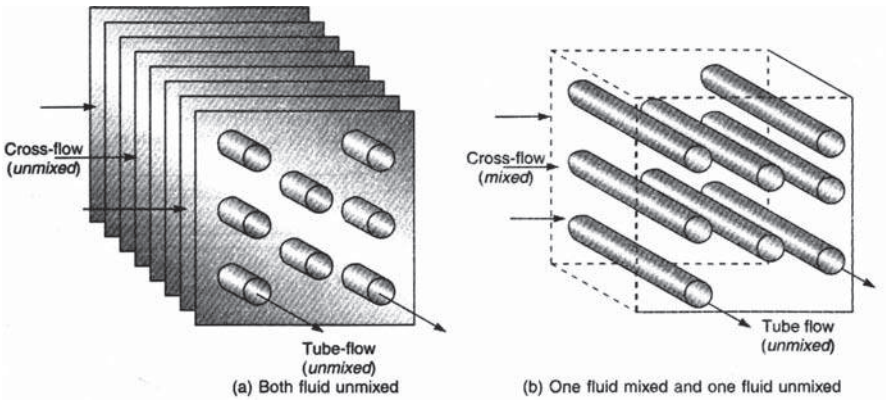


Fig. 8: Different flow configurations in cross-flow heat exchangers

flow in the opposite direction inside the heat exchanger as shown in Fig. 7b.

Cross flow heat exchanger: The hot and the cold fluids flow at right angles to each other. It can again be of two types: unmixed flow and fixed flow type. If both the fluids flow through individual channels and are not free to move in transverse direction, the arrangement is called unmixed flow (Fig 8a). On the other hand, if any fluid flows on the surface and free to move in transverse direction, then it is called mixed flow as shown in Fig. 8b.

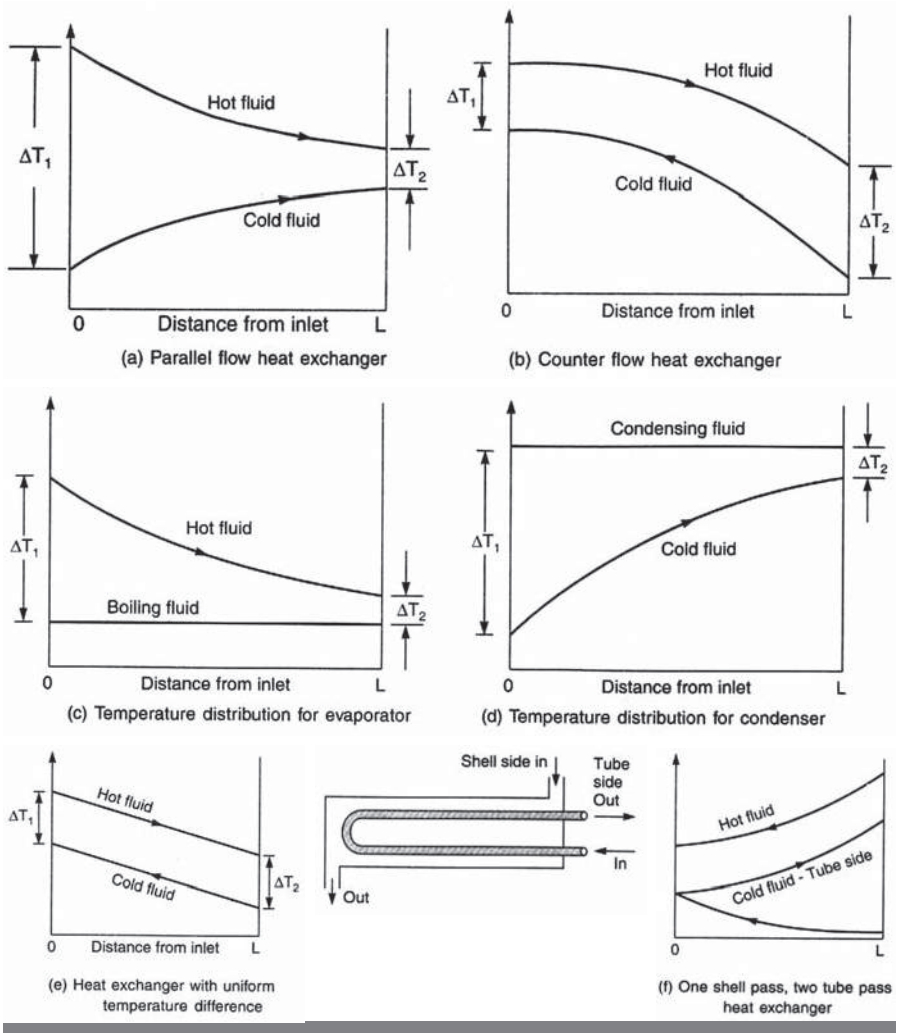


Fig. 9: Temperature profiles for different types of heat exchanger

Temperature Profile

In a heat exchanger, the heat transfer from the hot to the cold fluid results a change in temperature of one fluid or both the fluids. The variations of temperature of both the fluids for different cases have been shown in Fig. 9(a) – 9(f). The nature of variation of temperature plays an important role in the overall heat transfer between the two fluids. It has an effect on the heat transfer area, i.e., the size of the heat exchanger. Designers prefer to have more or less uniform temperature difference between the hot and the cold fluids throughout the length of the heat exchanger.

It can be concluded from the above figures that

- The temperature difference between the hot fluid and the cold fluid remains almost the same throughout the length in case of counter flow heat exchanger.
- In all other cases, the temperature difference is decreasing as the fluids move from inlet section to the outlet section.
- In case of evaporator and condenser, the temperature of one fluid remains the same throughout the length. So, the concept of parallel flow and counter flow has no effect there.

Overall Heat Transfer Coefficient

Normally, a heat exchanger involves two flowing fluids separated by a solid wall. The heat transfer rate is dependent on a quantity called overall heat transfer coefficient (U). The determination of U is the most difficult part in case of heat exchanger. It depends upon the heat transfer coefficients of the fluids on both sides of the wall (h_i and h_o) and also on the thermal conductivity of the wall in addition to geometrical dimensions of the heat exchanger. The flow and the thermal resistance between the two fluids in a double pipe heat exchanger have been shown in Fig. 10. The total

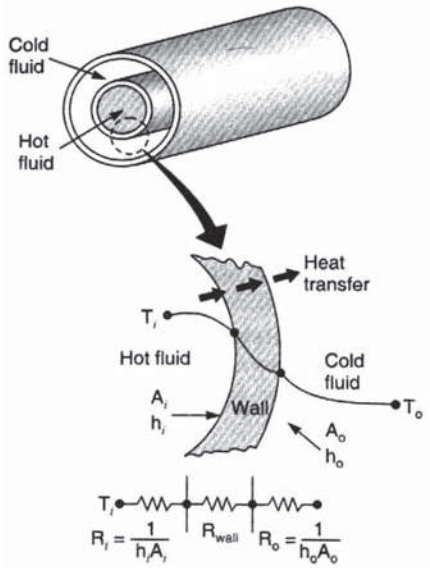


Fig. 10: Thermal resistance for a double pipe heat exchanger

resistance consists of two convective resistances on two fluid sides and one conductive resistance of the wall. The total thermal resistance is given by

$$R_{th} = \frac{1}{h_i A_i} + \frac{1n(d_0/d_i)}{2\pi LK} + \frac{1}{h_0 A_0}$$

Where, h_i and h_o are the heat transfer coefficients of the inner and the outer surface of the tube respectively, A_i and A_0 are the areas of the inner and the outer surfaces of the tube respectively, K is the thermal conductivity of the tube material. The heat transfer rate is calculated as

$$Q = \frac{\Delta T}{R_{th}} = UA\Delta T = U_i A_i \Delta T = U_0 A_0 \Delta T$$

Where U is the overall heat transfer coefficient expressed in W/m²K and can be written as

$$R_{th} = \frac{1}{UA} = \frac{1}{U_i A_i} = \frac{1}{U_0 A_0}$$

The overall heat transfer coefficient based on outside tube surface can be expressed as

$$U_0 = \frac{1}{\frac{A_0}{A_i h_i} + \frac{A_0}{2\pi LK} 1n(d_0/d_i) + \frac{1}{h_0}} = \frac{1}{\frac{d_0}{d_i h_i} + \frac{d_0}{2K} 1n(d_0/d_i) + \frac{1}{h_0}}$$

Similarly, the overall heat transfer coefficient based on inside tube surface can be expressed as

$$U_i = \frac{1}{\frac{1}{h_i} + \frac{A_i}{2\pi LK} 1n(d_0/d_i) + \frac{A_i}{A_0 h_0}} = \frac{1}{\frac{1}{h_i} + \frac{d_i}{2K} 1n(d_0/d_i) + \frac{d_i}{d_0 h_0}}$$

The average values of overall heat transfer coefficients for some common cases are listed in table I.

Physical Situation	U (W/m².K)
Brick exterior wall, plaster interior, uninsulated	2.55
Frame exterior wall, plaster interior uninsulated	1.42
With rock wool insulation	0.4
Plate glass window	6.2
Double plate glass window	2.3
Steam condenser	1100-5600
Feedwater heater	1100-8500
Freon-12 condenser with water coolant	280-850
Water to water heat exchanger	850-1700
Finned tube heat exchanger, water in tubes, air across tubes	25-55
Water to oil heat exchanger	110-350
Steam to light fuel oil	170-340
Steam to heavy fuel oil	56-170
Steam to kerosene or gasoline	280-1140
Finned-tube heat exchanger, steam in tubes, air over tubes	28-280
Ammonia condenser, water in tubes	850-1400
Alcohol condenser, water in tubes	255-680
Gas to gas heat exchanger	10-40

Table I: Approximate values of overall heat transfer coefficients, U

Fouling Factor

After certain period of operation, fluid impurities are deposited on the heat transfer surfaces of the heat exchanger. Rust formation on the surfaces and reactions between the surfaces and fluids are common phenomena.

This offers additional resistance to the heat transfer between the fluids. This effect is taken care by introducing one more thermal resistance called fouling factor Rf. Its value depends on fluid impurities, fluid velocity, temperature and the length of service of heat exchanger.

The deposition of solid particles can be cleaned off by scratching and chemical treatment of surfaces. Corrosion and other chemical foulings are common in chemical industries. This can be eliminated by coating metal pipes with glass layer or by use of plastic pipes. Besides these, growth of algae in the fluid may cause biological fouling. The fouling factor can be calculated as

$$R_f = \frac{1}{U_{dirty}} - \frac{1}{U_{clean}}$$

U_{dirty} and U_{clean} are the overall heat transfer co-efficient for dirty and clean conditions of the heat exchanger and can be found out experimentally. Considering fouling on both fluid sides, the total thermal resistance is written as

$$\Sigma R_{th} = \frac{1}{A_i h_i} + \frac{R_{f,i}}{A_i} + \frac{1n(d_0/d_i)}{2\pi LK} + \frac{R_{f,o}}{A_0} + \frac{1}{A_0 h_0}$$

$R_{f,i}$ and $R_{f,o}$ are the fouling factors at the inside and outside surfaces of the heat exchanger. The overall heat transfer co-efficient is then written for a tubular heat exchanger as

$$U_o = \frac{1}{\frac{d_o}{d_i h_i} + \frac{d_o}{d_i} R_{f,i} + \frac{d_o}{2k} 1n\left(\frac{d_o}{d_i}\right) + R_{f,o} + \frac{1}{h_o}}$$

and

$$U_i = \frac{1}{\frac{1}{h_i} + R_{f,i} + \frac{d_i}{2k} 1n\left(\frac{d_o}{d_i}\right) + \frac{d_i}{d_o} R_{f,o} + \frac{d_i}{d_o}\frac{1}{h_o}}$$

TEMA (Tubular Equipment Manufacturer Association) has

prepared a table for values of R_f as a guide line in heat transfer calculation The values of the fouling factor in some common applications are given in Table II.

Type of fluid	Fouling factor m2. K/W
Seawater, below 50°C	0.00009
Above 50°C	0.002
Treated boiler feedwater above 50°C	0.0002
Fuel oil	0.0009
Quenching oil	0.0007
Alcohol vapors	0.00009
Steam, non-oil-bearing	0.00009
Industrial air	0.0004
Refrigerating liquid	0.0002

Table II: Values of fouling factor in some common cases

Heat Exchanger Analysis

Heat exchanger analysis is quite complicated and involves flow parameters and geometry quite heavily. Some simpler methods of analysis are the Log-Mean Temperature Difference (LMTD) method and the Effectiveness- NTU method.

LMTD method for parallel flow heat exchanger

The analysis of a single pass parallel flow heat exchanger has been carried out. Let A be the heat transfer area in m^2 and

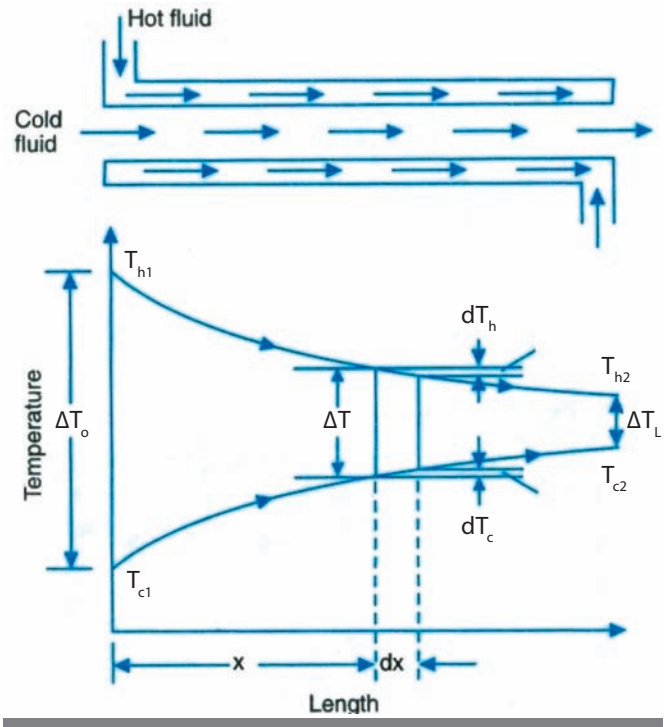


Fig. 11: Analysis of parrallel flow heat exchanger using LMTD method

m_c and m_h be the mass flow rates of cold and hot fluid. The situation is shown in Fig 11.

$\Delta T=T_h-T_c$ = Local temperature difference between hot and cold fluid in °C.

U = Local Overall heat transfer coefficient between two fluids, $W/(m^2,^0C)$

We can write,

$dQ = UdA\Delta T$ (1)

Also,

For hot fluid, $dQ = -m_h c_{ph} dT_h$ (2a)

For cold fluid, $dQ = -m_c c_{ph} dT_c$ (2b)

Again,

$\Delta T = T_h - T_c$ (3)

$\therefore d(\Delta T) = dT_h - dT_c$ (4)

$$\therefore d(\Delta T) = -\frac{dQ}{m_h c_{ph}} - \frac{dQ}{m_c c_{pc}} = -dQ\left(\frac{1}{m_h c_{ph}} + \frac{1}{m_c c_{pc}}\right) = -BdQ \quad (5)$$

where,

$$B = \left(\frac{1}{m_h c_{ph}} + \frac{1}{m_c c_{pc}}\right)$$

Combining (1) and (5), we get

$$\frac{d(\Delta T)}{B} = -UdA\Delta T$$

$$or, \frac{d(\Delta T)}{\Delta T} = -UBdA \quad (6)$$

Integrating,

$$\int_{\Delta T_0}^{\Delta T_L} \frac{d(\Delta T)}{\Delta T} = -B\int_0^{A_t} UdA$$

Where A_t is the total heat transfer area of the heat exchanger

or,

$$\int_{\Delta T_0}^{\Delta T_L} \frac{d(\Delta T)}{\Delta T} = -BA_t \frac{\int_0^{A_t} UdA}{A_t} \quad (7)$$

where,

$$\Delta T_0 = T_{h1} - T_{c1}, \Delta T_L = T_{h2} - T_{c2} \text{ and } \frac{1}{A_t}\int_0^{A_t} UdA = U_m$$

is defined as the average overall heat transfer co-efficient of the heat exchanger.

Then Eq. (7) becomes

$$\int_{\Delta T_0}^{\Delta T_L} \frac{d(\Delta T)}{\Delta T} = -BU_m A_t$$

$$Or, 1n\frac{\Delta T_0}{\Delta T_L} = BU_m A_t \quad (8)$$

The total heat transfer rate Q through the heat exchanger is obtained by integrating eq.(5) as

$$\int_{\Delta T0}^{\Delta T_L} d(\Delta T) = -B\int_{0}^{Q} dQ$$

$$\therefore \Delta T_0 - \Delta T_L = BQ$$

$$Or, Q = \frac{\Delta T_0 - \Delta T_L}{B} \quad (9)$$

Putting the value of B from Eq. (8) into Eq. (9) we get

$$Q = \frac{(\Delta T_0 - \Delta T_L)A_t U_m}{1n\left(\frac{\Delta T_0}{\Delta T_L}\right)} = A_t U_m \frac{(\Delta T_0 - \Delta T_L)}{1n\left(\frac{\Delta T_0}{\Delta T_L}\right)} \quad (10)$$

This can be written as

$Q = A_t U_m \Delta T_{lm}$

Where ΔT_{lm} is known as logarithmic mean temperature difference (LMTD). Therefore, total heat transfer rate Q for all single pass arrangement is given by

$Q = AU\Delta T_{lm}$

Special Cases:

(i) If $\Delta T_0 = \Delta T_L$, then $\Delta T_{lm} = \frac{0}{0}$ form, but in the limit applying L'Hospital's rule,

$\Delta T_{lm} = \Delta T_0 = \Delta T_L$

(ii) If ΔT_0 is not more than 50% greater than ΔT_L, the LMTD can be approximated by arithmetic mean within about 1.4 percent error.

Application of LMTD method for Multipass and cross flow heat exchanger

The flow conditions and temperature distributions for the fluids are somewhat complicated for multipass and cross flow heat exchanger. In these cases, approximate LMTD value can be obtained by introducing a correction factor F. Then, the LMTD can be written as

$\Delta T_{lm} = F\Delta T_{lm,\ counter\ flow}$

Where $T_{lm,\ counter\ flow}$ is the LMTD value for a counter flow arrangement with same hot and cold fluid temperatures.

The correction factor F depends on geometry of the heat exchanger and also on the inlet and outlet temperatures of the hot and the cold fluids. For some commonly used heat exchangers, the correction factor F can be obtained from the plots as shown in figure 12 -14. In those graphs, F is plotted as a function of dimensionless ratio, P called thermal effectiveness of the tube side fluid. P is defined as

$$P = \frac{t_2 - t_1}{T_1 - t_1}$$

T represents the shell side temperature and t represents the tube side temperature, subscripts 1 and 2 are the inlet and outlet conditions. A parameter R (called heat capacity ratio) is also defined as

$$R = \frac{(\dot{m}c_p)_{tube\ side}}{(\dot{m}c_p)_{shell\ side}} = \frac{T_1 - T_2}{t_2 - t_1}$$

In case of condensation and evaporation processes, one fluid remains at constant temperature, then either P or R will be zero and hence F will be unity.

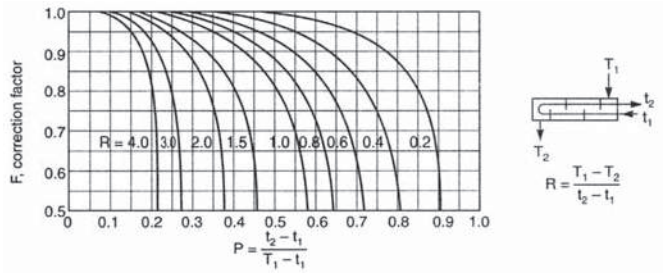


Fig. 12: Correction factor for one shell pass & two tube pass or multiple of two tube pass

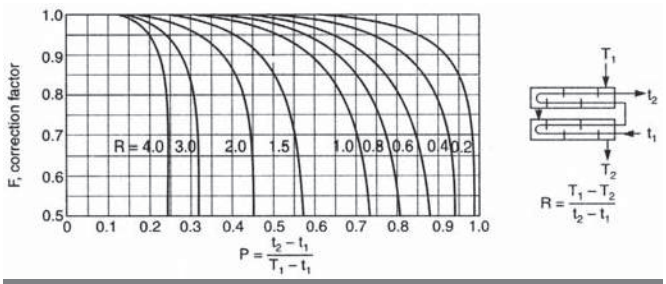


Fig. 13: Correction factor for two shell pass & four tube pass or multiple of four tube pass

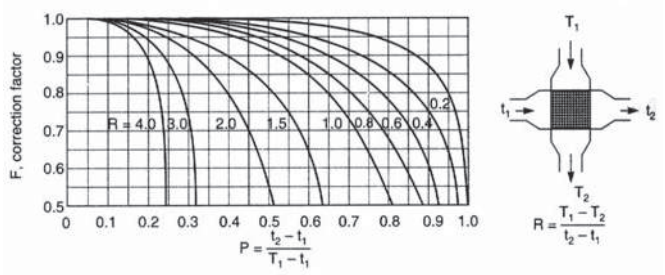


Fig. 14: Correction factor for cross flow, both fluid unmixed

Effectiveness- NTU ε-NTU Method

The rating and sizing of heat exchangers are the two important problems encountered in the thermal analysis of heat exchangers. The rating problem is concerned with the determination of the heat transfer rate, the fluid outlet temperatures, and the pressure drops for an existing heat exchanger or the one which is already sized; hence the heat transfer surface area and the flow passage dimensions are available. If the inlet and outlet temperatures of the hot and the cold fluid and the overall heat transfer coefficient are specified, the LMTD method, with or without the correction, can be used to solve the rating or sizing problem.

In some situations, only the inlet temperatures and flow rates of the hot and cold fluids are given, the overall heat transfer co-efficient can be estimated. For such situations, the logarithmic mean temperature can not be determined because the outlet temperatures are not known. Hence the use of LMTD method for the thermal analysis of heat exchangers will involve tedious iteration to determine the value of LMTD. In that case, the analysis is done by using Effectiveness –NTU (ε-NTU) method. Effectiveness (ε) of heat exchanger is defined as the ratio of actual heat transfer & the maximum possible heat transfer.

$$\varepsilon = \frac{actual\ heat\ transfer\ from\ one\ fluid\ to\ another}{maximum\ possible\ heat\ transfer\ from\ one\ fluid\ to\ another}$$

$$\therefore \varepsilon = \frac{Q}{Q_{max}}$$

The maximum possible heat transfer rate, Q_{max} is obtained with counterflow heat exchanger if the temperature change of the fluid having minimum value of mc_p equals the difference in the inlet temperatures of the hot and cold fluids. Here, we consider $(mc_p)_{min}$, because the energy given up by one fluid should equal that received by the other fluid. If we consider $(mc_p)_{max}$, then the other fluid should undergo a temperature change greater than the maximum available temperature differences, i.e., ΔT for the other fluid should be greater than $T_{h,in}$-$T_{c,in}$. This is not possible.

So, $Q_{max} = (mc_p)_{min}(T_{h,in} - T_{c,in})$

Then for a given ε and Q_{max}, the actual heat transfer rate is given by

$$Q = \varepsilon(mc_p)_{min}(T_{h,in} - T_{c,in}) \quad (1)$$

Determination of ε:

The effectiveness ε is given by

$$\varepsilon = \frac{Q}{(mc_p)_{min}(T_{h,in} - T_{c,in})} \quad (2)$$

Actual heat transfer rate Q is given by

$$Q = m_h c_{ph}(T_{h,in} - T_{h,out}) = m_c c_{pc}(T_{c,out} - T_{c,in}) \quad (3)$$

Putting the value of Q in Eq. (2) from Eq. (3), we get

$$\varepsilon = \frac{m_h c_{ph}(T_{h,in} - T_{h,out})}{(mc_p)_{min}(T_{h,in} - T_{c,in})} = \frac{C_h(T_{h,in} - T_{h,out})}{C_{min}(T_{h,in} - T_{c,in})} \quad (4)$$

Also, it can be written as

$$\varepsilon == \frac{C_c(T_{c,out} - T_{c,in})}{C_{min}(T_{h,in} - T_{c,in})} \quad (5)$$

Where $C_h = m_h c_{ph}$, $C_c = m_c c_{pc}$ and C_{min} is the smaller of C_h and C_c. We have the relation (already derived in the previous section)

$$1n\frac{\Delta T_0}{\Delta T_L} = BU_m A \quad (6)$$

For parallel flow arrangement, we have

$$\Delta T_0 = T_{h,in} - T_{c,in}$$

$$\Delta T_L = T_{h,out} - T_{c,out} \quad (7)$$

From Eq. (6),

$$\frac{\Delta T_0}{\Delta T_L} = e^{BAU_m}$$

$$\therefore \frac{\Delta T_L}{\Delta T_0} = e^{-BAU_m}$$

$$\therefore \frac{T_{h,out} - T_{c,out}}{T_{h,in} - T_{c,in}} = e^{-BAU_m} \quad (8)$$

Equations (4) and (5) are solved for $T_{h,out}$

$$T_{h,out} = T_{h,in} - \frac{C_c}{C_h}(T_{c,out} - T_{c,in}) \quad (9)$$

Putting the value of $T_{h,out}$ in Eq. (8), we get

$$\therefore \frac{T_{h,in} - \frac{C_c}{C_h}(T_{c,out} - T_{c,in}) - T_{c,out}}{T_{h,in} - T_{c,in}} = e^{-BAU_m}$$

$$\Rightarrow 1 - \frac{T_{c,out} - T_{c,in}}{T_{h,in} - T_{c,in}}\left(1 + \frac{C_c}{C_h}\right) = e^{-BAU_m}$$

$$Or, \frac{T_{c,out} - T_{c,in}}{T_{h,in} - T_{c,in}} = \frac{1 - e^{-BAU_m}}{1 + \left(1 + \frac{C_c}{C_h}\right)} \quad (10)$$

Putting this value in Eq. (5), we get

$$\varepsilon = \frac{1 - e^{-BAU_m}}{C_{min}/C_c + C_{min}/C_h} \quad (11)$$

Where $B = \frac{1}{C_h} + \frac{1}{C_c}$

For different flow arrangements, we should have different expressions for the effectiveness.

A dimensionless parameter called number of transfer units (NTU) is defined as

$$NTU = \frac{AU_m}{C_{min}}$$

Equ. (11) can now be written as

$$\varepsilon = \frac{1 - \exp[-NTU(C_{min}/C_c + C_{min}/C_h)]}{C_{min}/C_c + C_{min}/C_h} \quad (12)$$

Let $C = \frac{C_{min}}{C_{max}}$. Then, Eq. (12) can written as

$$\varepsilon = \frac{1 - \exp[-NTU(1 + C)]}{1 + C} \quad (13)$$

$$Since, if\ \frac{C_{min}}{C_c} = C, then\ \frac{C_{min}}{C_h} = 1$$

The above expression of effectiveness is for parallel flow arrangement. Similar expressions can be derived for other flow situations.

The expressions for effectiveness values for different flow geometries are presented in table III.

Effectiveness charts for various geometries

Kays and London have presented effectiveness charts for different types of heat exchangers as a function of NTU (N) and heat capacity ratio, C. These charts can be directly used for finding effectiveness for given NTU and C. The charts are presented in figures 15-20 for various geometries. After going through the charts minutely, the following points can be concluded:

- The effectiveness of all heat exchangers varies from 0 to 1.
- Effectiveness increases rapidly with NTU upto 1.5.

Flow Geometry	Relation for effectiveness
1. Double pipe heat exchanger	
(a) Parallel flow	$\varepsilon = \frac{1-\exp[-NTU(1+c)]}{1+c}$
(b) Counter flow	$\varepsilon = \frac{1-\exp[-NTU(1-c)]}{1-C\exp[-NTU(1-c)]}$
2. Shell and tube heat exchanger: One shell pass and 2,4, ……..tube passes	$\varepsilon = \left\{1+c+\sqrt{1+c^2}\,\frac{1+\exp[-NTU\sqrt{1+c^2}\,]}{1-\exp[-NTU(1+c^2)]}\right\}^{-1}$
3. Cross flow	
(a) Both fluid unmixed	$\varepsilon = 1-\exp\left\{\frac{NTU^{0.22}}{c}[\exp(1-cNTU^{0.78})-1]\right\}$
(b) C_{max} mix and C_{min} unmixed	$\varepsilon = \frac{1}{c}(1-\exp\{-c[1-\exp(-NTU)]\})$
(c) C_{min} mix and C_{max} unmixed	$\varepsilon = 1-\exp\left\{-\frac{1}{c}[1-\exp(-cNTU)]\right\}$
4. Boilers & condensers $c = \frac{C_{min}}{C_{max}} \to 0$	$\varepsilon = 1-\exp(-NTU)$

- NTU value larger than 3 will not be economically justified.
- For a specified value of NTU and C, the counter flow heat exchanger has the highest effectiveness and the parallel flow lowest. The effectiveness of cross flow heat exchanger is in between. This can be seen clearly from Fig. 19.
- The effectiveness for all heat exchangers is more close for NTU values less than 0.3 and it is independent of capacity ratio.
- For a given NTU, the effectiveness is maximum for C = 0 and minimum for C = 1.

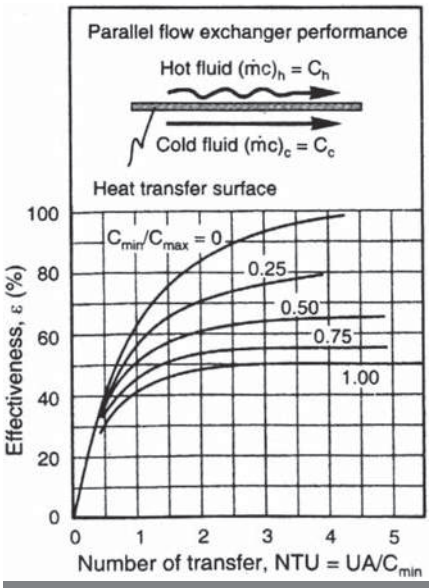


Fig. 15: Effectiveness for parallel flow heat exchanger

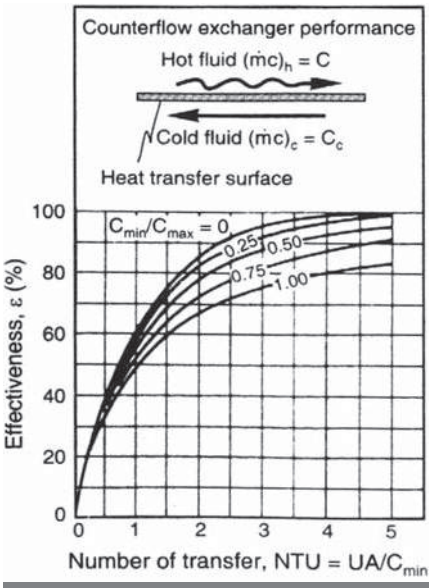


Fig. 16: Effectiveness for counter flow heat exchanger

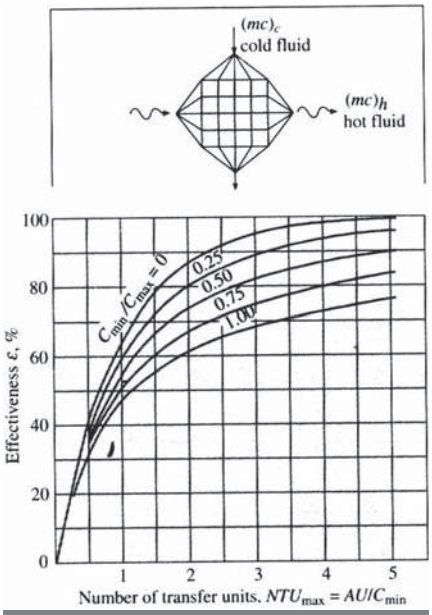


Fig. 17: Effectiveness for cross flow heat exchanger both fluid unmixed

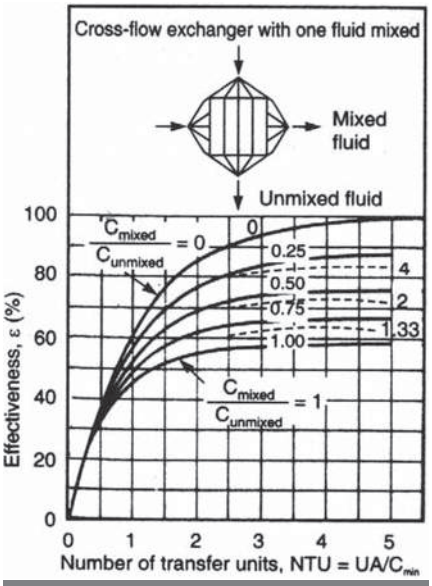


Fig. 18: Effectiveness for cross flow heat exchanger with one fluid mixed

- For C = 0 (condenser & evaporator), all heat exchangers will give the same effectiveness and is given by $\varepsilon = \varepsilon_{max} = 1-\exp(-NTU)$. The situations are shown in Fig. 21 and Fig. 22 for C = 1 and C = 0 respectively.

Physical significance of NTU

The dimensionless parameters NTU is defined as-

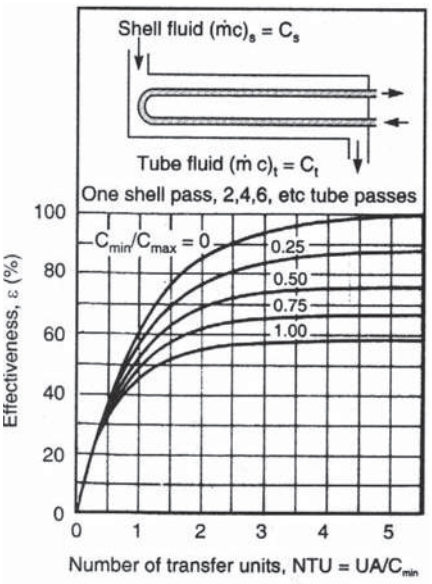


Fig. 19: Effectiveness for single shell pass with two, four etc. tube passes

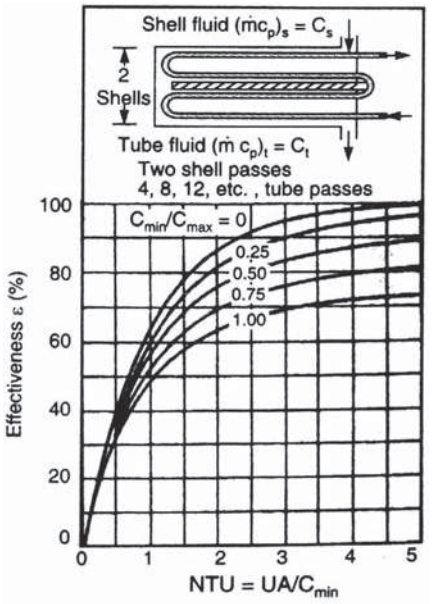


Fig. 20: Effectiveness for two shell pass with four, eight etc. tube passes

$$NTU = \frac{AU_m}{C_{\min}} = \frac{heat\ capacity\ of\ exchanger, W/^0C}{heat\ capacity\ of\ flow, W/^0C}$$

For a specified value of U_m/C_{min}, the NTU is a measure of the actual heat area A, or the physical size of the exchanger. The larger the value of NTU, the closer the heat exchanger approaches its thermodynamic limit. A counterflow heat exchanger has the highest

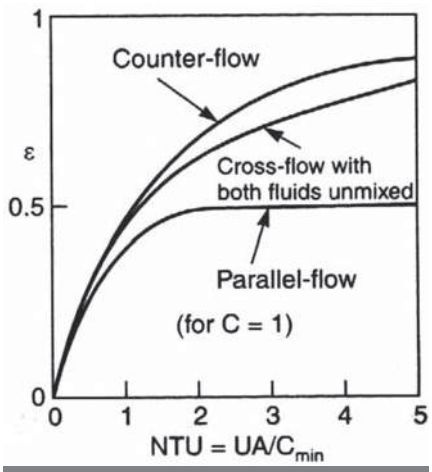


Fig. 21. Comparison of effectiveness for different flow arrangements for C = 1.

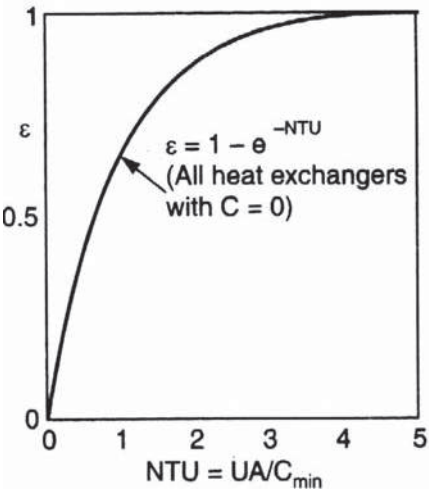


Fig. 22: effectiveness for condensers and evaporators for C = 0.

effectiveness (ε) for a specified values of NTU and C compared that with other for other flow arrangements. Therefore, for a given NTU and C, a counterflow arrangement yields maximum heat transfer performance.

Use of ε-NTU Relation

Rating problem

Inlet temperatures $T_{c,in}$, $T_{h,in}$, the flow rates m_c, m_h, physical properties of both fluids, overall heat transfer coefficient U_m and the total heat transfer A are all given. The type and flow arrangement for the exchanger are specified. We want to determine the total heat flow rate Q and the outlet temperatures $T_{h,out}$ and $T_{c,out}$.

Steps to be followed

- Find $C = \frac{C_{\min}}{C_{\max}}$ *and* $NTU = \frac{U_m A}{C_{\min}}$ from the given data.
- Knowing NTU and C determine ε (effectiveness) from the chart or equation for the specified geometry and flow arrangement.
- Calculate heat transfer rate as

$$Q = \varepsilon C_{\min}(T_{h,in} - T_{c,in})$$

- Calculate outlet temperatures as

$$T_{h,out} = T_{h,in} - \frac{Q}{(\dot{m}c_p)_h} \text{ and } T_{c,out} = T_{c,in} - \frac{Q}{(\dot{m}c_p)_c}$$

Sizing of heat exchanger

If the flow arrangement and the following data are available, then the dimensions of the heat exchanger can be found out and it is called sizing of the heat exchanger.

Available data

Inlet and outlet temperatures of the fluids: $T_{h,in}$, $T_{c,in}$, $T_{h,out}$ and $T_{c,out}$

Mass flow rates of the fluids: $\dot{m}_h$ and $\dot{m}_c$

Specific heats of the fluids: $c_{p,c}$ & $c_{p,h}$

Overall heat transfer Coefficient: U_o

To find

Heat transfer area or length of the heat exchanger

Using LMTD method

Steps

- Calculate heat transfer rate as

$$Q = \dot{m}_c c_{p,c}(T_{c,out} - T_{c,in}) = \dot{m}_h c_{p,h}(T_{h,in} - T_{h,out})$$

- Calculate LMTD, ΔT_{lm}
- Apply $Q = U_0 A_0 \Delta T_{lm}$
- Calculate length as

$$L = \frac{Q}{U_0(\pi d_0)\Delta T_{lm}}$$

Alternative method using ε-NTU method

Steps

- Calculate heat capacity ratio
- Calculate with known temperature
- Obtain NTU value from charts or relations
- Calculate area using the relation

$$NTU = \frac{U_0 A_0}{C_{\min}}$$

Hence, the length as well as heat transfer area of the heat exchanger can be calculated as above. ■

Spectrum of Corporate Responsibility

Corporate responsibility is an important factor to recognize when thinking about sustainability and the investment for large-scale energy reduction projects. Companies, big and small, sink barrels of money into these projects for a single purpose to live better.

Globalization has forever affected humanity. As more countries go online, they will need grid connection. Say, a continent the size of Africa decides to unite and come online tomorrow. Will we be facing one of the greatest challenges in our known history? The reality would be staggering. There would not be enough resources to go around. The air and water quality will be far worse than anything than we can imagine. Fortunately, those days are still ahead of us, and only one of many possible futures. Corporations see this as well, and are gearing up for a change.

The answer to our problems will lie in a broad scope of technologies, not just cutting the cord from fossil fuel. It will be of a fair and balanced solution that spreads resources around in a sensible way. The transition will not be easy, because let us face it, nothing is ever easy. However, the approach is what matters. The solution will come from a collective mastermind comprised of forward thinking individuals. People from opposite ends of the professional spectrum who are willing to put aside the political and scientific arguments for the sake of, again living better.

Let us face the facts. We as humans need three things to survive: Air, water and food. Everything else is arguable. If any of those becomes tainted we are in deep trouble. People are not stupid. They know these things need to be preserved, and at the end of the day, corporations do too.

India is a country that takes its role in globalization and corporate responsibility seriously. I know this because of the valiant effort their people are pushing forth to live sustainable, reduce waste, and conserve resources. There is a number of large-scale sustainable projects that are currently being implemented in states all across India including: Net-zero Universities, drastic changes to mechanical cooling, harnessing wind power, recycling raw waste, and even a potential ban on plastic. These are only a few examples, but enough to paint a fair picture of the effort to change for the greater good.

Even though I believe these projects represent the way we should all conduct our professional selves, a couple questions come to mind – Is there something missing from this equation? What about the small-scale effort? The small-scale effort I speak of would consist of projects "for the people" where similar strategies are

implemented to benefit the common man where it matters most – at home.

Do not get me wrong. I love the fact that Nalanda University, the oldest University in the world, is going green by becoming a net-zero campus. This is an institutional milestone, and a wonderful example for schools of the world to follow. Yet, I feel the companies implementing the net-zero design could reach a bit further, beyond the proposed residential campus. If they stretched their reach to the surrounding villages and went for true corporate responsibility, the additional building of net-zero homes for the locals would have a profound impact on the surrounding area, and be an ideal application to further their research. Setting an example and following through to show how their projects work on both a large and small scale, would show the masses the truth – that living better and creating a sustainable world is both possible and plausible for all classes. Not to mention, providing sources of personal comfort that may not have been available otherwise.

The idea of implementing the experimental Desiccant Enhanced Evaporative Air-Conditioning (DEVap) system into Nalanda University's net-zero design is a worthy undertaking. The DEVap technology has been tested and ready to be installed in large commercial applications, such as the University, but what about residential uses? Representatives from the National Renewable Energy Laboratory (NREL) say it would be soon to follow commercial systems. This may be an ideal opportunity for NREL to experiment with DEVap cooling systems on a smaller scale in nearby villages that do not have mechanical cooling or even in buildings that have less than sufficient systems. Implementing this system on a large scale and testing further on a small scale could produce the desired results needed to take the DEVap technology to market. Combining this technology with solar or wind installations as a power source, now gives you solid footing to produce the kind of business model needed to drive down costs while raising demand to make projects like this commonplace in the global economy.

Another project on the radar in terms of innovative large and small-scale applications is happening in New Delhi. This is the city where India's top students are leading the charge for future generations by harnessing the winds created by the high-speed railways and converting it to electricity. It is a free power source and even better, a byproduct of a necessary means of transportation for millions. In addition to focusing on New Delhi as a whole, there could be sub-teams of students assembled to apply the same calculations to set up affordable wind mills on homes in the area to help residents rely less on that same grid. Besides efficient ways to cool and produce energy, raw waste should be examined as another potential resource in the realm of sustainable living. Raw waste is an interesting form of garbage because of its methane producing qualities. Companies are harnessing this methane on a large scale to use as a fuel source, but when it's diverted from landfills it can be used as an equally effective means to solve the problems of the people. As I stated earlier, food is one of the three things we can't live without, and cooked food is the preference for most – unless you're a fan of the raw diet, which I personally am not. By setting up cooking stoves and similar technologies for local homes and business that could operate using raw waste as a fuel source, you can prove to the masses a viable solution to fuel shortages with a practical application. These cooking stoves are alternatives to traditional wood stoves that pollute the air and deplete our forests.

There are other ways to cut back on wasteful behaviors. Some are not so fun, and quite heavy handed plus difficult to implement, such as the proposed plastic ban in Pune. This is radical change, but still a strangely practical alternative to the rivers of plastic bottles flowing through the streets of Pune on a daily basis. It's my understanding that the solution for less plastic in Pune is to find alternative means for the storage and transportation of goods. One method people have come to embrace is something called, Biolice, an organic material made of cornstarch. It can be manufactured into bags and storage containers. This is good. It's a positive solution, but still, how do you spread word to millions who are hesitant to such a radical change? It is left up to those in charge, and those willing to perform a public service. They are the only ones who can solve this problem effectively by giving free lessons to people in their homes and businesses to physically show how to reduce their dependence on plastic while imparting consumers with the knowledge needed to change their everyday lives. This would benefit the greater good. It's the only way I see it possible to make the required change, and is up to those who lead to make it happen.

Looking at these examples, albeit if only a few pieces of a much larger puzzle, there are effective ways to reach the masses. Corporations working hard to live by their social and environmental responsibilities, hopefully, have not bit off more than they can chew. To have a positive affect on billions, not millions, the corporate brass should focus on broadening their scope. They need to reach people where it matters most at home. If the corporations could show people that they can implement these same strategies at home and on a budget, there can be a change. There can be a shift in global awareness, but it will depend on the will of the people in charge. I for one choose to believe in the power of good in all of those people. I like to believe they are using that power to benefit the common man. These are the beliefs that help me rest easy at night. ■

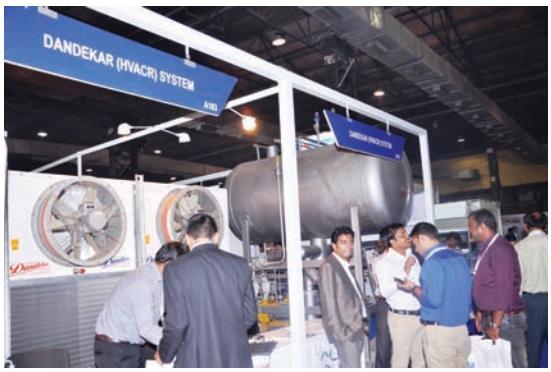
Ryan Rex, is a Project Manager and Engineering Coordinator. He is worked on mechanical projects emphasizing on energy reduction across the United States. In addition to his expertise in the mechanical trades, Ryan is an advocate for the Green Industry, and living a sustainable life.

India Cold Chain Show 2014, Mumbai

Cooling India participated at ICCS 2014, which took place from December 10-12, 2014 at Bombay Exhibition Centre in Mumbai. Once again exhibitors and visitors reaffirm that India Cold Chain Show is the hottest meeting place for business, discussions and opportunities for cold chain & cold logistics industry. The 3rd edition ended with about 115 exhibitors participating from 12 countries and 3816 professionals attending from over 30 countries.

India Cold Chain Show has positioned itself as the most important event for the industry. A notable growth and technological shift has been observed in the cold storage and cold transport sector which resulted to enthusiastic participation and representation of over 250 brands from Netherlands, England, United Stated, Germany, Spain, China, France, Italy and many more nations. The exhibition was attended by 3816 trade visitors from 34 countries including Australia, Iceland, India, Italy, Kuwait, Netherlands, Nigeria, Poland, Saudi Arabia, Singapore, Sri Lanka, Sudan, Thailand, Turkey, UAE, UK, USA and more.The opening ceremony of India Cold Chain Show on 10th December welcomed authorities such as Dr. Sudhanshu, Deputy General Manager from Agricultural and Processed

Food Products Export Development Authority (APEDA); Anil Kumar P, Deputy Director, Marine Products Export Development Authority (MPEDA); M L Arora, CEO, Fresh & Healthy Enterprise, Subsidiary of Container Corporation of India Ltd (CONCOR); S.N.A Jinnah, Chief General Manager



representing National Bank for Agriculture & Rural Development (NABARD) and Wouter Verhey, Agricultural Counsellor from Embassy of the Netherlands.

Anuj Mathur, Managing Director of Reed Manch Exhibitions highlighted efforts and support of the trade bodies by saying, "I am delighted to inform you that India Cold Chain Show has been able to consistently deliver value to its participants, visitors and stakeholders. This year with support from National Center for Cold Chain Development (NCCD) and related trade bodies we have been able to focus largely on agricultural side of the cold chain development." The president of Federation of Cold Storage Associations of India (FCAOI), Mahendra Swarup said, "I am happy that Reed Manch has been playing a crucial role in bringing the industry together for years now. And with Cold Chain Awards added to the program, we are extremely delighted that the hard work and initiatives taken by industry members are being appreciated."During this edition, the Netherland, UK and Reverse Logistics pavilions appeared for the very first time, which opened doors to new business opportunities for Indian counterparts.

In parallel to the exhibition, a two day. 'India Cold Chain Summit' was organised on December 10-11, which gave attendees a chance to network, learn and meet who's who of the industry. Based on the theme 'Exploring new strategies and avenues to expand cold chain business in India' the conference brought together 336 delegates. The next India Cold Chain show will take place on December 16-18, 2015. ■

ARCON 2015, January 31, Navi Mumbai

Ammonia Refrigeration (AAR) is a national organization, dedicated to promote safe use of ammonia as refrigerant through education, information and standards for the people and organizations to understand the efficient use of ammonia refrigeration. For use of ammonia as a refrigerant, an International exposition & Seminar on Indian Refrigeration Industry, "ARCON" in 2014 was organised. The association is once again organizing 2nd National Convention on Ammonia Refrigeration Systems i.e. ARCON-2015, an International Exposition & Seminar on Indian Refrigeration Industry being organized at Hotel Four Points by Sheraton, Vashi, Navi Mumbai on January 31, 2015. Apart from the seminar, Panel Discussions and Product Presentations the event also includes an exhibition wherein various refrigeration products, systems and services will be offered to the participants & delegates. ■

2015 AHR Expo January 26-28, Chicago

The management organising show announced, that three new all-time records have already been established for the world's largest HVACR event. As of the first week in January, there were more than 2,100 exhibiting companies occupying over 480,000 sq ft of exhibit space – both new records for 67th event. The 2015 AHR Expo will be at least 10% larger than the previous largest Show and feature 8% more exhibitors than last year's event in New York City. Included are 380 companies that have never exhibited in the Show before. Another new all-time record is the number of international exhibitors showcasing their products and solutions. This year, 592 international companies from over 30 countries will be exhibiting in Chicago, representing a 16% increase over the previous record. "Chicago is always where our largest Shows take place," said Clay Stevens, President of International Exposition Company, which produces and manages the AHR Expo. Pre-registration is currently running ahead of the last Chicago Show in 2012, which was the attendance record at that time. Mayor R. Emanuel has declared January 26-28 "Air Conditioning, Heating & Refrigerating Week in Chicago". AHR Expo is endorsed by 38 HVACR industry associations and is co-sponsored by ASHRAE and AHRI. ■

ACREX India 2015, Bangalore

ACREX India is returning to Bangalore after a show at Delhi where the event saw participation from over 400 exhibitors and nearly 30,000 visitors. Being organised by the ISHRAE & produced by NuernbergMesse India Pvt Ltd, ACREX India 2015 will be conducted at India's only LEED Certified Green Exhibition Centre Bangalore International Exhibition and Centre (BIEC) with over 40,000 sq mtr of fully covered and air conditioned space. ACREX India is growing phenomenally every year and is becoming the launch platform for many International Organisations like, UNEP, CIBSE, REHVA, EBTC, AMCHAM, US Commercial Services, VDMA Germany, KRAIA Korea and CAR China to network with the Indian Industry. The expo in its 2014 edition, for the first time, garnered support from the Ministry of New and Renewable Energy. ACREX India 2015 will create new benchmarks by developing on these industry associations. The expo is also getting support from Indian associations like IGBC and BEE. The event expects around 400 exhibitors besides knowledge enhancing workshops. ACREX 2015 announces Refrigeration and Cold Chain pavillions.

Green and Sustainability Industry meet held in Mumbai

On January 17, 2015, an interesting interactive panel discussion on 'Sustainability and Green Building Movements: An assessment of their Impact' was held in Mumbai at

Sahara Star Hotel. The welcome address of the event was given by NurnbergMesse India representative, followed by presentation on ACREX India 2015. The elite gathering was addressed by V Madhava Rao, Chairman ACREX India 2015 followed by small presentation by Voltas. Panel members included Dr. Aniruddha, Head- health Safety environment, Tata Consultancy Services; Pankaj Dharkar, MD, Pankaj Dharkar Associates; M. Gopikrishna, EVP and Chief Operating Officer, Domestic Projects Group, Voltas Ltd, Mumbai; Satish Jamdar, MD, Blue Star Ltd; Prof. Rajan Rawal, Diirector, Centre for Advanced Research in Building Sciences and Energy, Ahmedabad; Arch. Nilabh Nagar, Senior Associate, Architect Hafeez Contractor. The discussion was moderated by K Ramchandaran, Director, Eskayem Consultants Pvt Ltd. Vote of thanks was delivered by V Krishnan, Member ACREX India vision Group & Past President ISHRAE. ■

Bitzer at India Cold Chain Show 2014

BITZER showcased its ECOLINE VARISPEED, ORBIT 6 scroll compressors and other highlights at India Cold Chain Show. BITZER already supports its Indian customers in four cities through its Green Point service network.

Powerful under all operating conditions

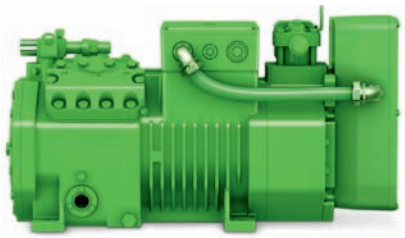
- Lower operating costs: the ECOLINE VARISPEED
- Efficient under full and part-load: ORBIT scroll compressors
- Compact and powerful: the ECOSTAR
- Close to the customers: four Green Point centres in India.

With 80 years of experience, long-standing company BITZER presents application-specific compressor solutions for the Indian refrigeration and air-conditioning sectors at the India Cold Chain Show, held during December 2014 in Mumbai.

'Refrigeration and air-conditioning technology is very important in India', explains Rob de Bruyn, Managing Director of BITZER Refrigeration Asia. He added, in vast regions of India, which is second only to China in terms of population, the climate is sub-tropical or tropical. Intact cooling chains are therefore crucial for transporting fresh food to its destination. With the reliability and quality of BITZER, we are able to provide a great deal of support to the people on site whilst benefiting from the opportunities for growth in India.

Infinitely adjustable cooling capacity
ECOLINE VARISPEED

ECOLINE VARISPEED Reciprocating compressors offer high cooling capacity and reliability, as well as excellent energy efficiency. With their internal frequency inverters, the speed control can be infinitely adjusted to suit the operating conditions perfectly. This minimises suction pressure fluctuations & cycling rates, which in turn reduces operating costs. ECOLINE VARISPEED does not require regular maintenance or a fan as suction-gas-cooled operating elements ensure that the temperature of the electrical components remains optimal.



ECOLINE VARISPEED reciprocating compressors offer high cooling capacity and reliability, as well as excellent energy efficiency

Efficient: ORBIT scroll compressors

Efficient, reliable and best suited to air-conditioning systems and heat pumps – this is the series of ORBIT scroll compressors from BITZER. They offer a high isentropic efficiency and are highly energy-efficient under both full and part-load. ORBIT compressors are available in two case sizes, the ORBIT 6 and ORBIT 8. The displacement of the ORBIT scroll compressors ranges from 20 to 77 m^3 per hour (50 Hertz). Other advantages of the ORBIT series are their low sound levels, wide range of applications and the innovative oil management system BAHT.

The patent-pending BITZER Advanced Header Technology (BAHT) is designed for scroll compressor tandems and trios and makes it easier to combine even or uneven compressor sizes in a parallel circuit in air-conditioning and heat-pump systems. The newly developed suction gas header with integrated oil distribution plays a key role in this improvement, directing oil to one of the compressors in the tandem and trio units – and from there distributing it among the other compressors.

Efficient, reliable and best suited to AC systems and heat pumps – this is the series of ORBIT scroll compressors

Compact performance

ECOSTAR is one of the highlights of the India Cold Chain Show. The compact, air-cooled condensing unit is distinctively energy-efficient and compatible with a wide range of applications. The cooling capacity of the BITZER ECOSTAR can be adjusted to best suit the actual requirements thanks to the speed control of the compressor and condenser fan. Precise temperature control increases the efficiency of the refrigeration system and reduces operating costs. The internal control enables quick and easy installation of the condensing unit.

Optimised for high ambient temperatures in India – LH265

Another BITZER highlight at Show was air-cooled LH265 condensing units with semi-hermetic reciprocating compressors for universal applications. In its factories in Schkeuditz (Germany) and Jakarta (Indonesia), BITZER adapts compact screw compressor units to suit the special operating conditions in India. This way, the LH265 condensing units run reliably and safely even with outside temperatures of up to $49^{O}C$. This makes them vastly superior to similar condensing units which exceed their maximum compressor operating parameters at just $43^{O}C$. LH265 condensing units are easy to install and quick to commission.

Green Point

The refrigeration compressor specialist has been expanding its Green Point network in India since 2011. The project offers comprehensive maintenance & other services for compressors. The first Green Point in India opened in Delhi in March 2011, followed by others in Mumbai in November 2011, Bangalore in July 2013 and Kolkata in May 2014. 'We have carefully selected the geographical locations of our Green Points', explains Harvinder Bhatia, Country Manager of BITZER India. 'With branches in the north, west, south and east of India, as of October 2014 we have repaired around 1,800 compressors in our Green Points – quickly and reliably.' ■

Refrigerant Recovery Unit

Recover all commonly used refrigerants (CFC,HCFC,HFC),includind R410A.
1/2 HP&1HP,oil-less compressor recovers both vapor and liquid refrigerant quickly.
Heavy duty industrial grade condenser and cooling fan.
Oil separator device for recyling refrigerant.
High pressure safety Shut-off switch.
Fiter/Drier removes both moisture and acid from the refrigerant.
Ergonomic and compact design makes it easy to carry and use.
Design fo residential,commercial and automotive A/C system.
Optional 80% capacity shut off kit to prevent from overfilling the storage tank.
Suitable for all the main voltage standard in the world. ■

Website:www.aitcoolinc.com

Vacuum pump

Designed specially for HVAC/R service.
Ultimate deep vacuum:single stage is 2Pa,while dual voltage is 2×10^{-1}Pa.
Compact design with aluminum housing and easy to carry.
Thermal protector in the motor guarantee the pump to run steadily.
Both 1/4" and 3/8" SAE flare inlet connections allow for flexibility of connections.
Vacuum pump oil included.
Individual design for special customers.
Suitable for all the main voltage standard in the world. ■

Wenling AITCOOL Equipment Co.,Ltd
Xiazaiwu Industry Zone,Shiqiaotou Town,Wenling City,Zhejiang,317500,China
Tel: 0086-576-81622550 Fax: 0086-576-81622660
E-mail:sales@aitcool.com
Website:www.aitcoolinc.com

Refrigerant Recovery System

Recovery/recycle/vacuum/charge
Electron balance protection system for impact absorption
Large size dual condenser installation
Large size graphic lcd(240×128)
Work progress red wheel basis installation
Operating method is easy progressive form display screen and membrane keyboard
Fine digital electron balance(10g/50kg)
Core type large size dry filter
High temperature/high pressure compressor for only refrigerant
Station vacuum pump full automatic injection function
Automatic discharge function for waste oil
Automatic air purge/tank safety valve system
Automatic refrigerant transfer and tank receipt
Overpressure power prevention and inside protection system
Refrigerant injection amount memory function for all models of car
Multilanguages support
3"1/2 inch large size gauge only for refrigerant (made in china)
16kg recovery tank 3000mm high pressure hose only for refrigerant
SD card to enter the vehicle with infinity,and other infrormation refrigerant(Easy upgrade) ■

Website:www.aitcoolinc.com

AITCOOL

Aitcool inc.,founded in 2007, is a professional national High-Tech enterprise,specializing in researching, developing and manufacturing refrigeration tools for HVAC/R,with an annual capacity of 30,000 refrigerant recovery machines and 200,000 rotary-vane vacuum pumps at present.AITCOOL has the most professional mechanical, electrical, refrigerating senior engineers.

In March 2008, AITCOOL achieved the invention patent of refrigerant recovery machine;

In October 2008, our refrigerant recovery machine project was approved by Ministry of national science and technique.

In October 2010, AITCOOL was honored as national High-Tech enterprise;

In September 2011, Our automatic refrigerant recovery machine project was approved by National Economic Commission.

With the high quality and advanced technology, the joint efforts of all our colleagues, which guarantee AITCOOL healthy development over a long period,All products have obtained china patents and got theEuropean CE,American UL certificate,CSAcertificate,etc.,and also achieved ISO9001 certificate, exported to more than forty countries,including USA, South America, EU, Australia, Southeast Asia, Middle East, Japan,etc.. our products with high quality and competitive price is no doubt your best choice. ■

Website:www.aitcoolinc.com

Gandhi Automations offers High Performance Doors

High Speed Doors designed & manufactured by Gandhi Automations Pvt Ltd, are sturdy, dependable and are the ideal solution for medium and large entrances. The doors are manufactured with European collaboration and technology with innovative and creative engineering. Fast moving functional and reliable doors are needed in industrial and commercial contexts. Gandhi designed and manufactured High Speed Doors are versatile and solid ensuring long-lasting reliability. The modular structure of the curtains, assembled and joined by anodized aluminium extrusions, provides for a wide range of polyester sections available in a variety of colours. Wide, full-width window panels ensure a safer traffic and allow more light in. Their fast and easy replacement, in case of accidental tearing, saves money and time. The alternating metal tubular structure there inserted ensures high wind-resistance. Prime doors are the ideal solution for internal and external entrances and effectively operate in any situation, even when strong winds are blowing, in rooms with high volume traffic. Sturdy and dependable, Prime is the intelligent door for medium and large entrances. ■

Website:
www.geapl.co.in

Hongsen Ball Valves from Smart Marketing

These are one of the most sold products in Hongsen range of controls and valves for Refrigeration & Airconditioning systems. These Ball Valves are available with or without port for charging and inspection that is with or without Schrader Valve. Compatible with all HCFC and HFC refrigerants, Hongsen Ball Valves can be used for a wide temperature range of -40^{0}c to +150^{0}c, hence suitable for any airconditioning, refrigeration or even freezing system. Each valve is electronically tested for leakage before despatch.
Main features of Hongsen Ball Valves are:
No pressure drops in flow.
Only 1/4" turn makes valve full open or full close, which is marked on Valve's stem.
No chance of inside liquid accumulation.
Valve stem is designed for explosion proof. ■

For further details:
marketing@smartmarketing.co.in

DX380 by Dotech Inc

Suitable for multi control of air compressor. Cutting edge electronic controller performing efficient operation of multi compressor system. Big Graphic LCD for many languages. Automatic recovery from CPU down by noise. RS485 communication, perfect interface with upper system mounted MODBUS RTU International Standard Protocol. Analogue output (Pressure Re-Trans. Signal). Unified body possible to build in optimized system embedded various function and high efficacy. Big Graphic LCD for many languages (Korean, English, Chinese, etc). ■

Website:
www.dotech21.com

T6 Hydrocarbon refrigerant hydrocarbon-charging machine by Shaoxing Cacl Digital Control Co Ltd

The two guns two systems design, realization two refrigeration online hydrocarbon-charging. Charging R290, R600a, R32 etc which are hydrocarbon, mainstream refrigerants. Strict security configuration: MSA alarm system 24 hours and safety testing. Wind pressure testing. Pulse resolution 1/10g precision vortex flowmeter. Rearmounted guide plunger hydrocarbon-charging gun. Configuration barcode gun, to identify as many as 99 channel mix the chiller production line. RS232 / RS485 communication interface. The centralized control system. Equipment systemic explosion-proof design.

Main Configuration
Mitsubishi motors PLC and HMI, Data module.
CACL precise vortex flowmeter or RHEONIK Mass flowmeter.
CACL – IDB intelligent double class balance cylinder (double).
CACL pure pneumatic efficient booster pump (double).
CACL-H5AG after arrive open technology Gun (double).
MSA safety alarm system.
Site ventilation and wind pressure alarm system. ■

Website:
www.china-cacl.com

ALM brings Aerosense Air Flow Measuring Station

ALM Engineering & Instrumentation Pvt Ltd., offers Duct Mounted and Airflow Measurement Station. The air flow measuring station is easy to install. The instrument utilizes an airflow averaging element in a head-type device, generating a differential(velocity) pressure signal similar to the orifice, ventury and other head producing primary elements. Strategically located sensing ports continuously sample the total and static pressures when inserted normal to flow. Total pressures sensed by the upstream ports are continually averaged within the airflow element in an isolated chamber. The static sensing ports are averaged in a second isolation chamber. Multiple element are joined together for connection to a differential measurement device (gage, transmitter, etc) for flow measurement and indication purposes.

Specifications:

Accuracy: +/- 3%; temperature: Maximum operating, 350 deg F.
Maximum Designed Flow: 6000 feet per minute; casing: CRCA duly powder coated. ■

Website:
www.almontazar.com

Twiga Flexible Ducts by UP Twiga Fiberglass Limited

Twiga Flexible Duct designed for HVAC systems is strong, light weight, fully flexible, compressible yet dimensional stable. The inner part is made up of laminated films permamantly bonded to a coated tough steel wire helix. Thermal efficiency is provided by wrapping exterior of the inner core with a blanket of fiberglass wool insulation in various density and thickness as per the required thermal resistance.

Application and Benefits

Ideal for all air-conditioning and ventilating systems in hospitals, hotels, industrial, residential, commercial and office buildings. ■

Website:
www.twigafiber.com

Filter Drier for Car A/C by Nantong OEM Refrigeration Equipment Co Ltd

The refrigerant must be clean and dry before entering into expansion valve, otherwise the expansion valve will be blocked by impurities or ice. To avoid these, one need to install a filter drier before the refrigerants enters into the expansion valve. It filtrate the scrap iron and welding slag, absorbs the water into system, special design on connections can eliminate vibration exists during driving.

Features

Shock resistant steel shell construction finer. 25μm final outlet pad keep maximum filtration with minimal pressure drop. Highly corrosion-resistant powder coating finish. Can be used in all environments, including marine applications. ■

Website:
www.filterdrier.cn

A-flex Class 1 Closed Cell Elastomeric Nitrile Insulation Sheet/ Tubes by ALP

ALP Aeroflex India Pvt Ltd introduces A-flex is a flexible thermal insulation material made from closed-cell, elastomeric nitrile rubber. ALP-A-flex is produced in pre- formed sheets and pipe sections. These products meet insulation requirements in diverse fields such as the automobile, air conditioning & refrigeration industry, construction segment, hospitals, pharma industries, hotels and cold storage industries.

Product Features

Completely closed cell elastomeric nitrile insulation.
Quick and easy to install with no special tools.
Flexible, durable and easy to handle.
Excellent compression strength due to closed cell structure.
Contains no chlorinated or dangerous substance.
Superior thermal insulation properties over other open or closed cell insulation material due to high water vapor resistance property of nitrile rubber.
Very high diffusion resistance and no cladding required if installed inside.
Class 1 fire safety as per BS 476 part 7. ■

Website:
www.alpaeroflex.com

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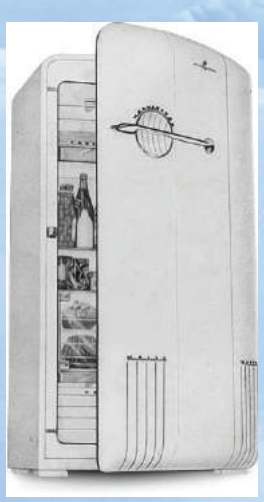
Museum Tower uses heat pumps in pursuit of LEED Gold

Luxury implies a superabundance that verges on wasteful, while efficiency or "eco-friendly" implies either making do with less or going without altogether. The Museum Tower residential high-rise in downtown Dallas hopes to be a happy marriage of the two. The 42 story, 560 ft tower is the tallest residential structure to be completed in the city in more than 20 years. Owned by the Dallas Police and Fire Pension System, the tower includes 115 one, two- and three-bedroom condominiums that range from 1,800 sq ft peid-á-terres to a 9,000 sq ft penthouse. Luxury features include striking contemporary architecture, balconies, floor-to-ceiling glass walls, private elevator entry and access to a host of amenities including outdoor recreational areas, a state-of-the art fitness center and 24-hour valet and concierge services. At the same time, the building is designed to achieve LEED Gold certification. Much of the construction was done with sustainably-sourced building materials. The design maximizes the use of natural light. Faucets and fixtures are low-flow, and toilets are high efficiency. But far and away the most LEED points come from the heating and cooling system. A total of 335 Climate Master Tranquility 20 Single-Stage Series vertical and horizontal water source heat pumps were installed, as well as two Tranquility Large Series horizontal water-source units. Individual units ranging from 3.5-tons to 25-tons were specified for each residence. The system was designed by Blum Consulting Engineers. "The main goal was two-fold," said Jack Musick, PE, project manager at Blum, "to be able to sub-meter the electrical usage of each condo unit, and also to achieve an ultra-high level of efficiency with the HVAC system's operation."The company that installed the mechanical systems for the entire building was Don Burden & Associates, a contractor that's been working in Dallas since 1975. The firm has roughly 150 permanent employees (with some temporary help as the workflow demands) and handles as many as six or seven projects at a time. "We specialize in new construction," said Ray Hamilton, senior project manager for Don Burden & Associates. "We do not do service at all. Probably one of the few who don't, but we're just not geared for that." Don Burden & Associates was on site only a month after the ground-breaking in June of 2010 placing sleeves for some of the larger piping. Now that construction is complete, Don Burden technicians are still out at Museum Tower making modifications to condos as they are sold. Because if luxury means anything, it means having things just the way you want them. ■

Advances in mechanical refrigeration for US residential and commercial use from the late 19th century up to 1960

The collection includes many examples of advances in mechanical refrigeration for residential and commercial applications, dating from about 1890 to 1960. Such devices dramatically improved food storage safety and convenience and set high standards for mechanical reliability. The RRM collection contains products of such pioneers in the refrigeration industry as Frigidaire, Philco, Sunbeam, and Tecumseh. An archive is available to help researchers trace the history of the refrigeration industry. Contributions to this archive include pioneers such as Jim Alter of Harry Alter Catalog and a 1933 interview with Edmund Copeland. A Crosley "Icy Ball" (in operating condition): These refrigerators were made for farms before rural electrification (approximately after World War II). Ammonia and water charged (after regeneration over a kerosene burner), the box temperature of 43 degrees Fahrenheit could be maintained over a 24- to 40-hour period, while making ice cubes. General Electric monitor-top refrigerators (in operating condition): Said to be a refinement of the Audiffren machine, three types are shown that were produced in the 1930s and 1940s. The first Copeland "Copelametic" compressor. The first 1/2 horsepower Copelamatic compressor to come off the production line was colorimeter tested in the Copeland laboratory and is now on display. The semi-hermetic systems was developed by correcting problems found in the "pollywog" compressor produced in 1932. Limited production then began with 1/6 and 1/5 horsepower single-cylinder compressors. The first production run of 100 Copelamatics was for the Coca-Cola Company of Dayton, Ohio. ■



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